MINERALS AND ENERGY BRANCH

REPORT OF ACTIVITIES

2001

REPORT ME 2002-1
ED. D. R. MACDONALD

NOVA SCOTIA
Natural Resources

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Honourable Tim Olive
Minister

D.J. Graham
Deputy Minister

Halifax, Nova Scotia
2002

Cover photo

Underground photograph of Saddle-reef (Vein 2a) at the EnviroGold Dufferin gold deposit located near Sheet Harbour, eastern shore of Nova Scotia. Photo taken by R. J. Horne. The auriferous vein material is located in the hinge zone of the Crown Reserve Anticline and the vein represents the second of 13 individual or zones of stacked saddle-reefs within the deposit, identified from surface drilling and underground development (Fall/Winter 2001/2002). The small circular shapes in the photographed face are drillholes that are part of the preparation for blasting. Camera is facing west and geologist shown for scale.

Note that the saddle is dominated by massive quartz; however, this thick vein thins on the margins (i.e. into the floor) where it becomes a laminated quartz vein with typical ribbon or crack-seal texture. Significant slate inclusions, both obvious and as ghost images, occur within the saddle reef and their significance is discussed by Horne (p. 51-67) in this volume.

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Progress Report on the Stratigraphy and Structure of the Kingsville Salt Deposit (NTS 11F/14), Inverness County, Cape Breton Island, Nova Scotia[1]

R. C. Boehner

Introduction

This work and progress report are part of the Nova Scotia Department of Natural Resources contribution to the federal-provincial Targeted Geoscience Initiative (TGI) project. The Cape Breton Island TGI project is a joint project of Natural Resources Canada (Geological Survey of Canada) and the Province of Nova Scotia (Department of Natural Resources) and operates between 2000 and 2003.

The Kingsville salt deposit is located near Kingsville in the southwestern end of the River Denys lowland, approximately 20 km north of the Port Hawkesbury-Point Tupper industrial area on the Strait of Canso (Figs. 1, 2 and 3). The Cape Breton area was investigated for its salt and potash potential by Hayes (1931). Although no salt springs or indications of salt were found in the Kingsville area, many were described in the River Denys Valley near the Whycocomagh, St. Patricks Channel, Orangedale, and Bucklaw areas, and near Dundee-West Bay. Deep exploration drilling for salt was initiated in the Kingsville area between 1968 and 1971 by Domtar Limited (1968, 1969, 1971) on the significant Bouguer gravity anomalies in the area (Domtar, 1968).

Domtar Inc. (1978) also considered the deposit for possible development of an underground salt cavern for petroleum storage. The Kingsville deposit is attractive because of the potentially large salt resource present and it is located approximately 20 km north of ice free, deep water port facilities on the Strait of Canso. The complex geology of the deposit, especially the stratigraphy and structure, was not well defined within individual drillhole sections or between adjacent sections. Further exploration and development work on the deposit by Domtar ceased in 1978. Currently, there is renewed interest in use of the Kingsville deposit for underground storage, as well as other similar deposits in the region.

Based on a preliminary review of the Domtar Inc. (1978) report describing the geology of the deposit, including drill logs, maps and cross-section plots, indications of fold repetition were recognized. These included the symmetrical (inverted) repetition of interstratified anhydrite, carbonate and red to green siliciclastic units identified within several of the salt-dominated drillholes. A selection of the drillholes, including DK-3, -4, -5, -9, -10, -11 and -12, was examined in the summer 2001. These were used to investigate the carbonate and anhydrite strata that serve as the key markers to document internal stratigraphy, structure and correlation of the deposit (Boehner, 2001). A progress report on the results of this study is presented here.

Geology

The geology in the Kingsville area (Fig. 3) was described in geological maps and reports by Kelley (1967) and Lynch and Brisson (1996). The two highland ridges that border the area are the Creignish Hills to the northwest and North Mountain to the southeast (Raeside and Barr, 1990). The Creignish Hills comprise late Proterozoic to early Paleozoic metamorphic and intrusive rocks and represent the basement rocks to the overstepping Carboniferous basin strata. The

[1]Contribution to the Targeted Geoscience Initiative project: Geological Mapping for Mineral Development in South-central Cape Breton Island. Funded by Natural Resources Canada and the Nova Scotia Department of Natural Resources.

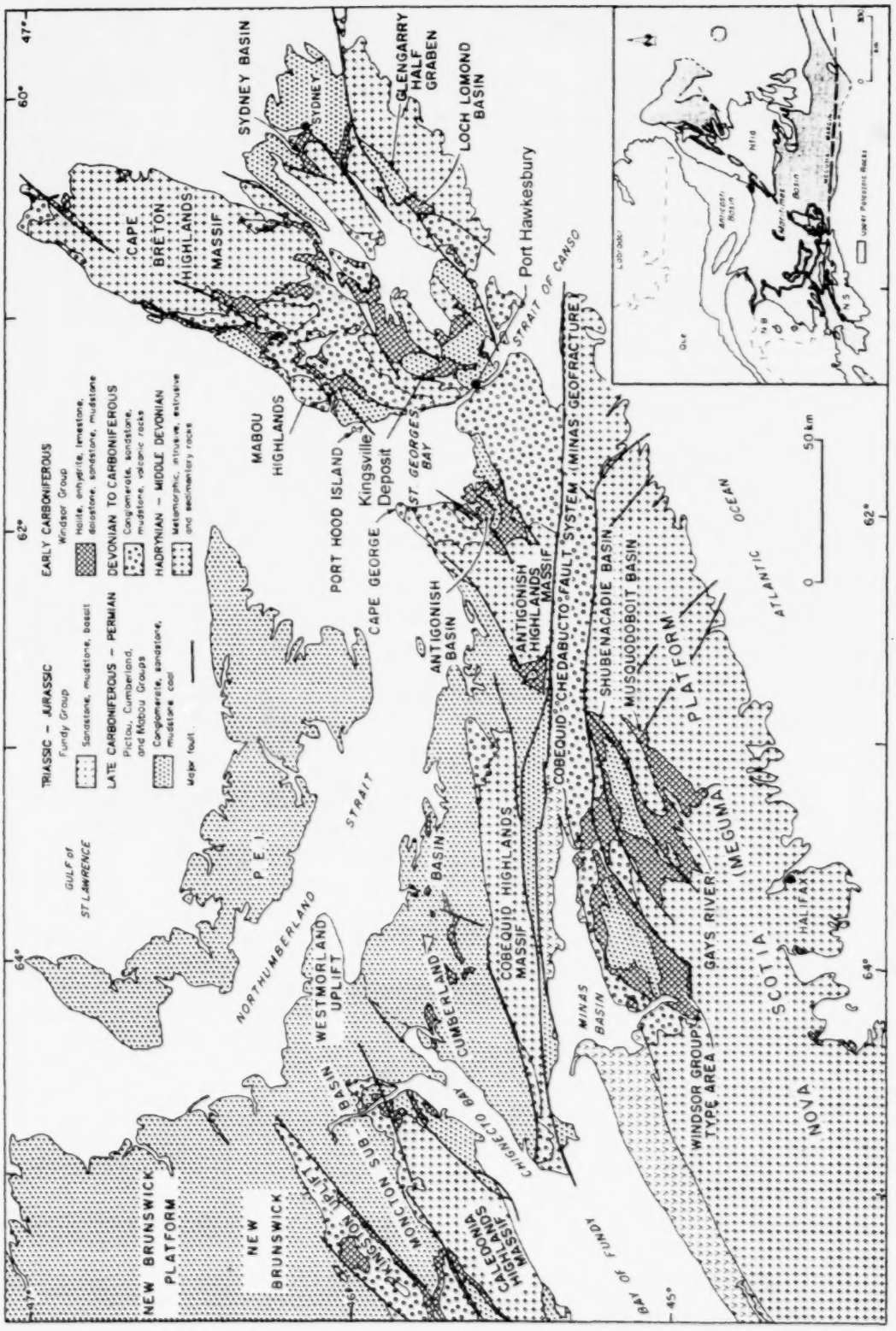

Figure 1. Regional geology and location map, Nova Scotia.

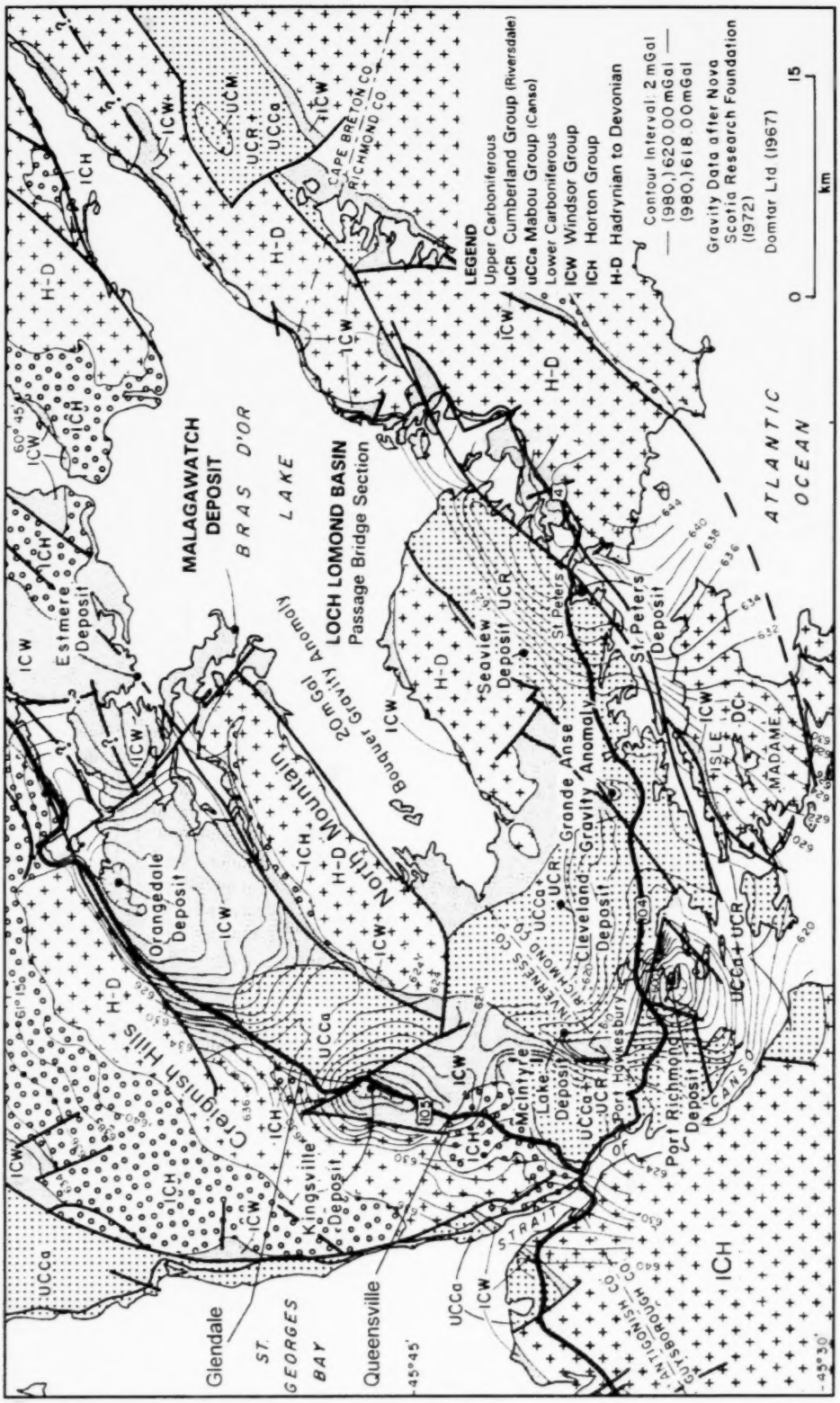

Figure 2. General geology and Bouguer gravity anomaly map, south-central Cape Breton Island.

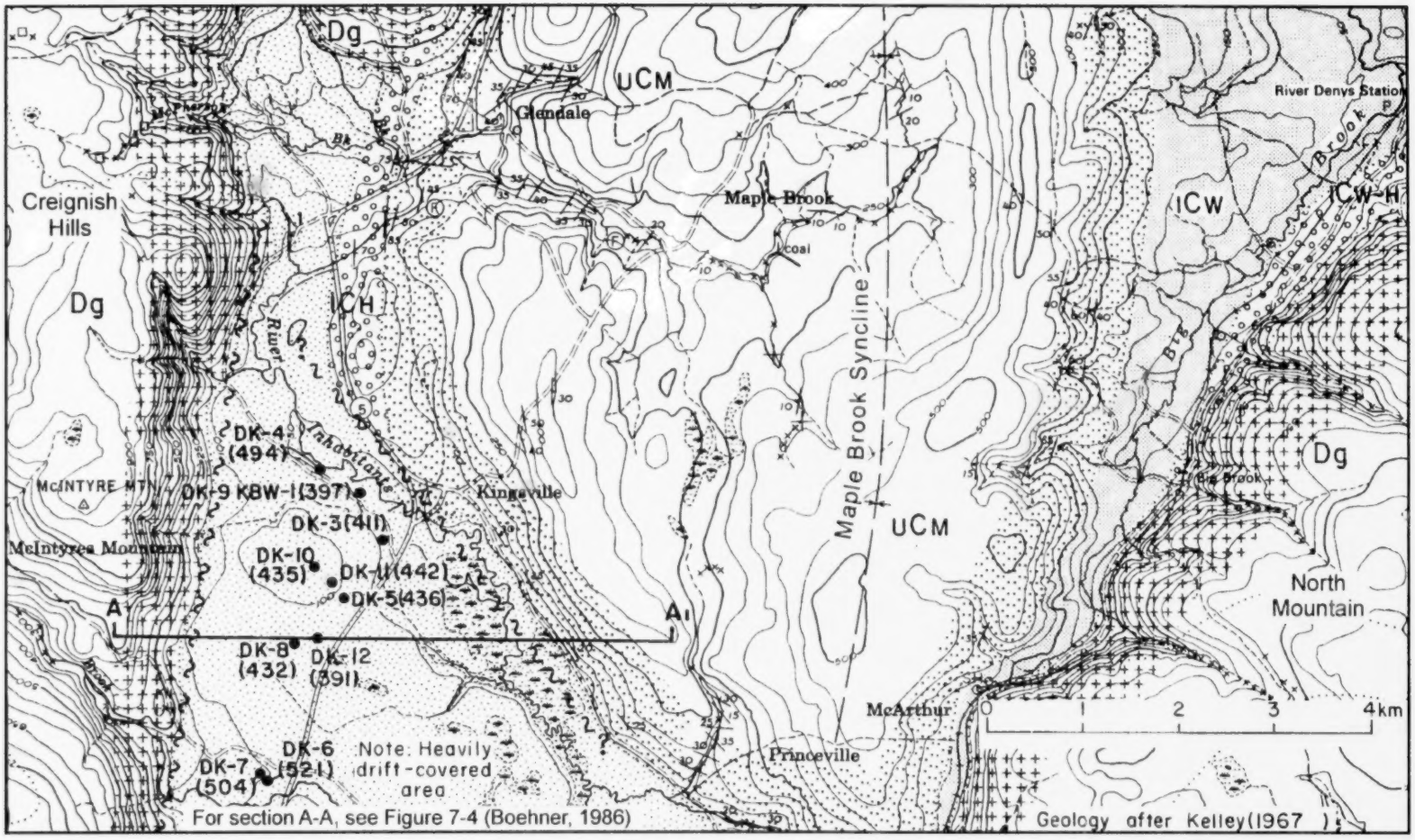

Figure 3. Geology in the vicinity of the Kingsville Deposit, Inverness County.

complex of metamorphic rocks in the Creignish highlands have been mapped as the George River Group or Blues Brook Formation of Raeside and Barr (1990). These include quartzo-feldspathic and micaceous quartz schist, quartz gneiss, limestone, quartzite, minor volcanic rocks and greywacke of late Proterozoic age (Hadrynian) age. These rocks have been intruded by Ordovician dioritic and granitic rocks. In addition, there are small areas of late Proterozoic gneiss (Bras d'Or metamorphic suite) that occur in association with the George River Group.

The Lower Carboniferous Horton Group, Strathlorne-Ainslie Formation, onlaps the older rocks of the highlands and occurs in a narrow outcrop band to the north near Glendale where the geology is obscured by thick drift cover. To the north of Kingsville, the Windsor Group is in fault contact with Mabou Group strata along the northwest border of the Maple Brook Syncline. Upper Carboniferous strata in the Maple Brook Syncline define a broad syncline in the central lowland area. These relatively resistant rocks of the Mabou and Cumberland groups form prominent hills with elevations of up to 200 m that separate the River Denys and River Inhabitants areas.

Windsor Group rocks outcrop both north and south of the Maple Brook Syncline. North Mountain, like the Creignish Hills, comprises Ordovician dioritic and granitic intrusives, Proterozoic gneiss (Bras d'Or metamorphic suite), and George River Group (Malagawatch Formation of Raeside and Barr, 1990) metasedimentary and volcanic rocks of late Proterozoic age (Hadrynian). These older rocks are overlain by a stratified section of sandstone, conglomerate and siltstone which Kelley (1967) mapped as marginal facies of the Horton Group and/or Windsor Group. This unit occurs in a narrow outcrop band between Big Brook and River Denys Station. This section is overlain with uncertain relationship by Windsor Group strata, which occur in a southerly narrowing outcrop band beneath the Mabou Formation in the Maple Brook Syncline. The area is included on a recent geological map of Whycocomagh (11F/14) by Lynch and Brisson (1996).

The deep salt exploration drilling by Domtar Limited at Kingsville (Figs. 3 and 4) indicates the present geological maps of NTS areas 11F/11 and 11F/14 require revision and re-interpretation, especially in the area of the map sheet borders. A new map of NTS area 11F/11 is currently in preparation by Giles *et al.* (2001). Previously unmapped faults may explain this discrepancy. The contact between the Windsor Group (salt section) and the pre-Carboniferous to the west is interpreted as a major fault that brings the very thick section of saline Windsor Group (drilled depths exceeding 1200 m) in contact with Hadrynian to Devonian granitoid and metamorphic rocks that comprise the Creignish Hills (Figs. 3 and 4). This contact zone is a dramatic north-south topographic break where the crystalline basement rocks of the highlands rise abruptly to elevations approximately 250 m above the lowlands. The lowlands are underlain primarily by the evaporitic Windsor Group and thick surficial valley fill (presently the River Inhabitants system), where elevations are approximately 30 m with little local relief. Lynch and Brisson (1996) identified a north-south fault at the northern end of the inferred west border fault to the Kingsville deposit.

The northern and southern boundaries of the Kingsville deposit are complicated by inferred fault blocks of Horton Group strata (southwest of Glendale and north of Queensville). The Horton Group outcrop pattern in the Glendale area (Fig. 3) is conspicuously narrow, indicating a thin onlap configuration or, alternatively, a fault contact with the underlying basement rocks of the Creignish Hills. The contact area is further complicated by the fault contact juxtaposing Mabou Group rocks of the Maple Brook Syncline with the thin basal Windsor Group and Horton Group strata outcropping in the narrow zone between Glendale and Melford. The Horton Group in the Queensville area, in contrast, has a wide (several km) outcrop pattern and variations in bedding orientations indicate some folding and local faulting. A block of Horton Group and overlying Macumber Formation and basal anhydrite of the Windsor Group has been mapped in the area northeast of Queensville (NTS 11F/11) by Giles *et al.* (2001). This block strikes north-northeast into the southern end of the Kingsville salt deposit (near drillholes DK-6 and DK-7, Figs. 3 and 4). Similar to the relationship at Glendale, a fault is inferred to be present to

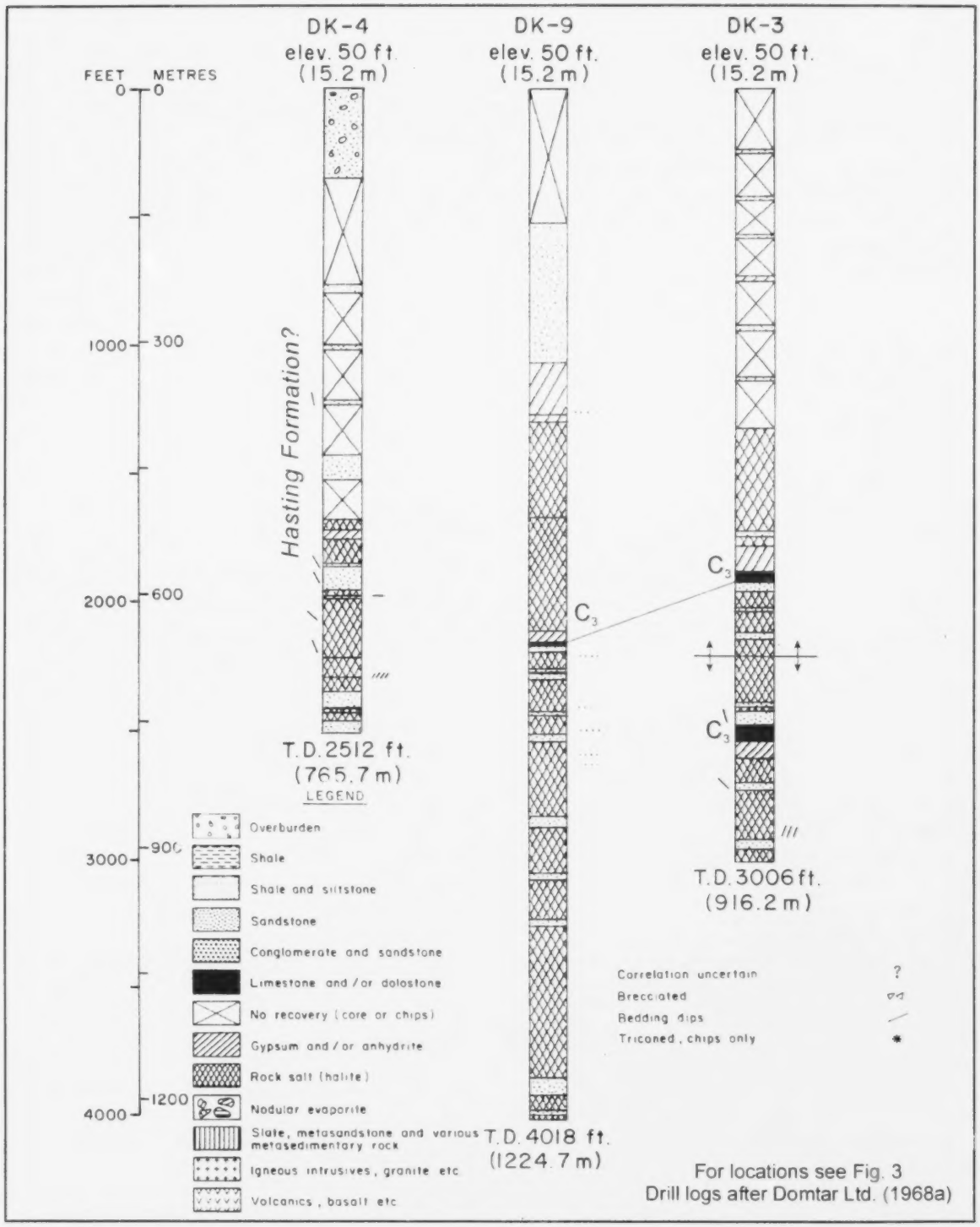

Figure 4. Drillhole profiles, Kingsville deposit, Inverness County.

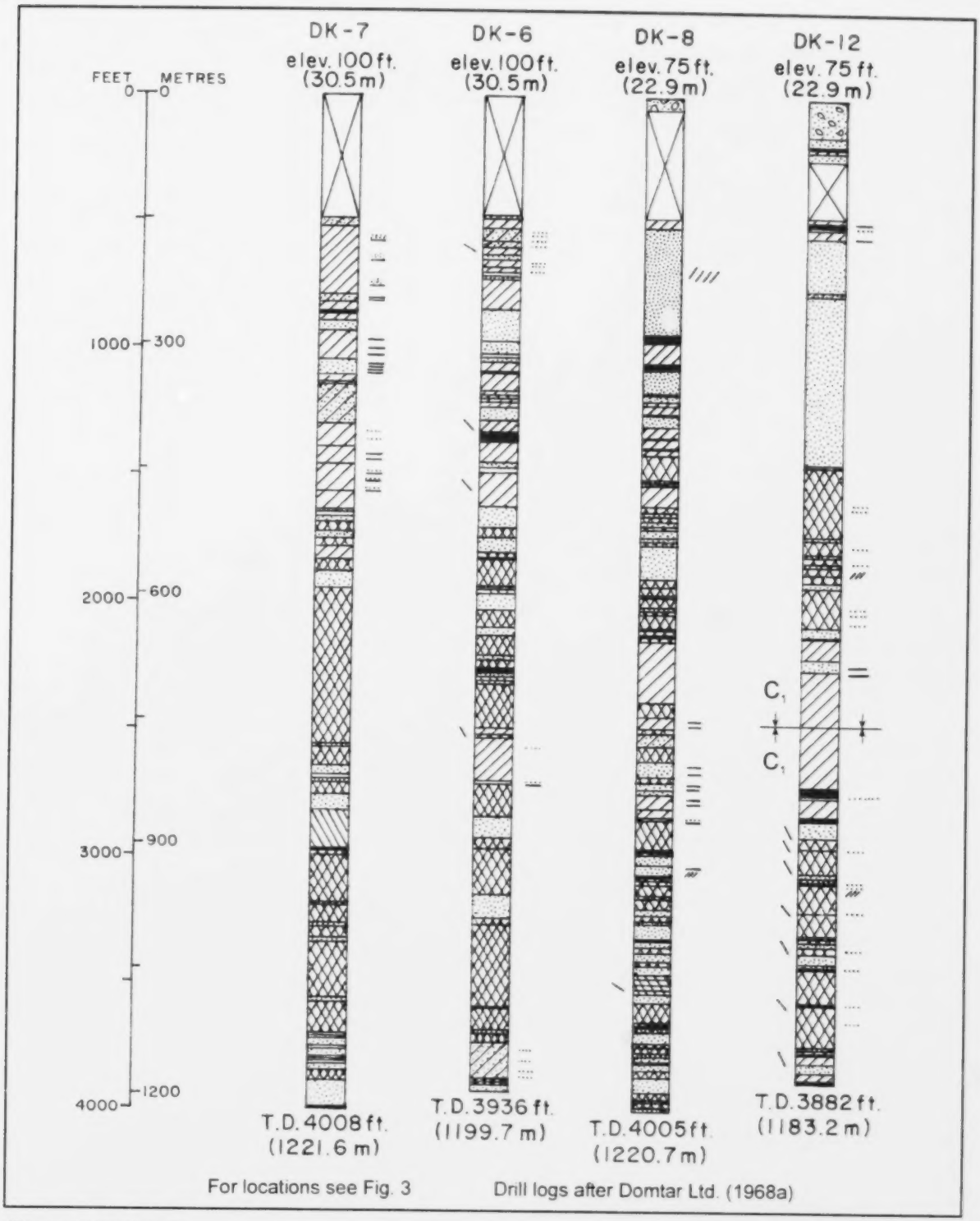

Figure 4. (Continued).

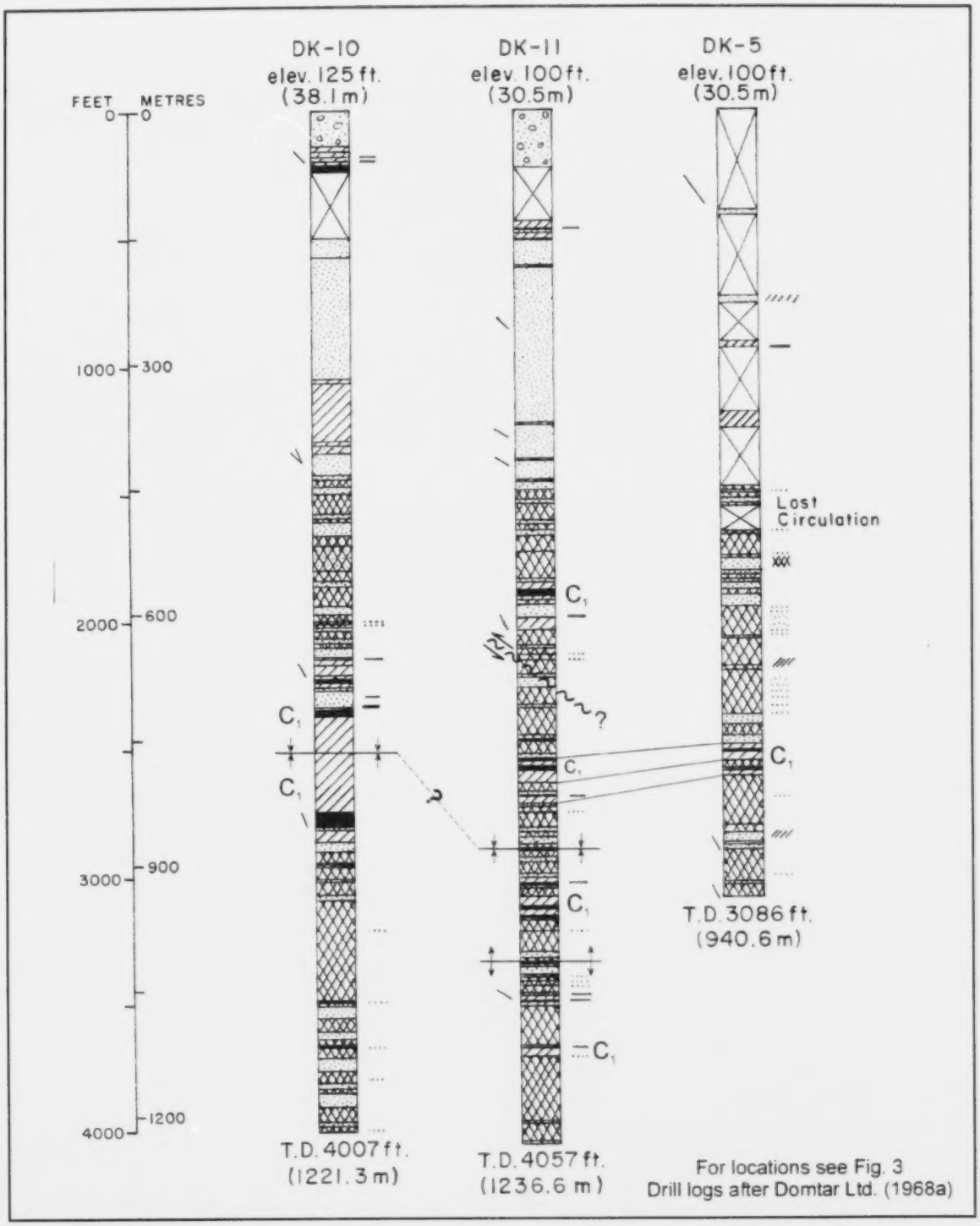

Figure 4. (Continued).

separate the extremely thick, saline Windsor Group at Kingsville from the Horton Group rocks that outcrop in Lamey Brook located approximately 1.5 km south of Domtar drillholes DK-6 and -7.

A major lineament paralleling River Inhabitants along the western limb of the Maple Brook Syncline may reflect the possible position of a major fault bounding the northeastern side of the salt mass. The only Horton/Windsor and Mabou rocks that outcrop in the immediate area of the Kingsville deposit occur near Highway 105 along River Inhabitants to the north of the Domtar drillholes. Kelley (1967) and Lynch (1996) indicate steeply dipping Horton Group and basal carbonate (Macumber Formation) of the Windsor Group juxtaposed with Mabou rocks of the Maple Brook Syncline. This relationship is typical of the Ainslie Detachment that occurs as a low-angle fault in the region. The relationship may also be produced by a high-angle fault with normal or reverse relative movement.

The area in the vicinity of the Kingsville salt deposit is included on Nova Scotia Research Foundation Bouguer gravity anomaly map of Whycocomagh (Domtar, 1968) at a scale of two inches equals one mile (Figs. 3 and 5). The presence of salt, indicated by the large, high amplitude (16 mGal) Bouguer gravity low, has been confirmed in diamond-drill holes. The Bouguer gravity anomaly coincident with the salt is oriented approximately north-south and parallels the western border fault (Figs. 2, 3 and 5). Although the precise structural configuration of the salt mass is not clear, abnormal thickening, very steep dips and fold repetition are apparent in this complexly folded structure (Fig. 4). A structural setting similar to that described by Giles (1981a and 2001) in the McIntyre Lake deposit area may be present in the Kingsville deposit. Further comparison will require additional detailed examination of drill core from the Kingsville deposit.

The Kingsville salt deposit was briefly described by Boehner (1986) and more detailed descriptions and data are provided by Domtar Inc. (1978), who completed much of the exploration work on the property in the late 1960s to early 1970s. Domtar Limited (1968) made a preliminary review of potential Maritime salt deposits and selected Kingsville, St. Peters and Seaview for diamond-drill testing the following year. The first hole drilled at Kingsville (Kingsville No. 3, Figs. 3 and 4) intersected salt at 376 m (1235 ft.) and was terminated in salt at 916 m (3006 ft.). Because all the Kingsville exploration holes were drilled using feet as depth measurements, both SI and Imperial measurements are used for reference. Encouraged by the success of this hole an additional nine holes (nos. 4 to 12) were completed at Kingsville to depths of approximately 1220 m (4000 ft.) in 1968-1970. Based on the exploration drilling data, a solution mining test well (KBW No. 1) was drilled in 1971 near Kingsville No. 9 in a nearly vertical-dipping section of high-grade salt at the northern end of the Kingsville deposit. This hole, completed at approximately 1220 m (4000 ft.), was fitted with a large diameter production casing for the brining test that was begun near the bottom of the well. The test indicated that brining was a satisfactory method to extract salt from the Kingsville deposit.

The Kingsville deposit is geologically complex and the full limits have not been defined by drilling. The exploration holes were drilled as a series of four northwest-southeast transects along a north-northeast-trending strike line. Spacing between the transects is approximately 600 m to 1200 m. Domtar geologists interpreted the structure as a diapiric antiform with a long, arcuate, anticlinal fold axis through these four drill panels. The fold axis was indicated to strike northeast-southwest to near north-south, with steep fold limbs and a plunge to the south. Approximately eight salt sections were recognized and utilized in correlation and definition of resource blocks for potential solution mining for salt or development of underground storage cavities. Domtar Inc. (1978) reported salt reserves of 1.152 billion tons in the drilled area of approximately 2400 m (8000 ft.) long by 900 m (3000 ft.) wide to a depth of 1220 m (4000 ft.). Depth to the top of first salt ranges from approximately 400 m to 500, with the greater depth in the south end of the deposit area.

Domtar Inc. (1978) indicated that blocks of salt appropriate for potential brine production cavities were outlined in every drillhole except DK-4.

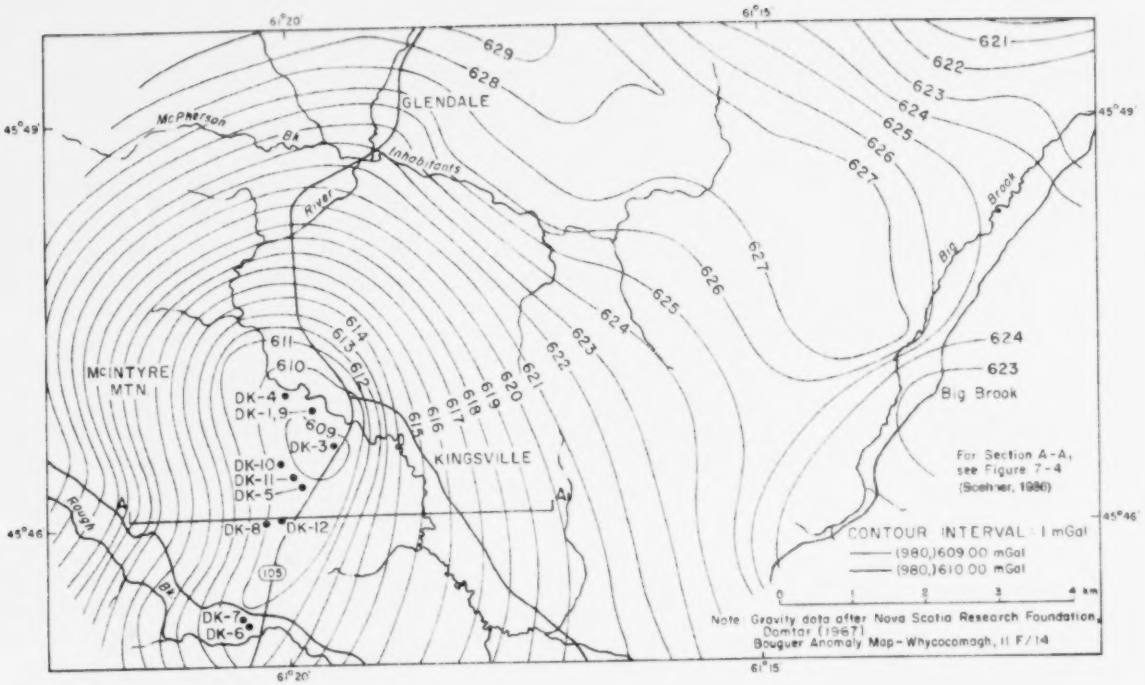

Figure 5. Bouguer gravity anomaly map, Kingsville deposit, Inverness County.

which was a shallow hole of 765.7 m (2512 ft.). Drillholes DK-6, 7 and 9 were considered to offer the best potential for developing large cavities. Reserves of over 10 million tons of approximately 90% NaCl were identified in DK-6 and -7, with 5 million tons of approximately 90% NaCl identified in DK-9.

A preliminary review of the drill logs, maps and plots in the Domtar Inc. (1978) report indicated the probable presence of fold repetition of interstratified anhydrite, carbonate and red to green siliciclastic units within the salt-dominated stratigraphy. This interstratified succession is typical of Major Cycles 2 to 5 of the Windsor Group. Sections of salt strata typical of the lowermost Windsor Group Major Cycle 1 are not apparent in the available information. In the summer of 2001, the drill core available from drillholes DK-3, -4, -5, -9, -10, -11 and -12 was examined to identify the major stratigraphy and structure of the deposit (Boehner, 2001). Inverted and normal minicycle sequences of the strata typical of Major Cycles 2-5 are indicative of folds with suspected repetition over drill core intervals of less than 500 feet to over 1000 feet (e.g. DK-10, -11, -12). The identification of this type of folding, which is well documented at nearby deposits near Malagawatch and Orangedale, will require further investigation through detailed core logging and analysis.

Boehner (2001) described a very distinctive section of anhydrite with limestone and dolomite beds occurring at depths of approximately 600-900 m in drillholes DK-10 and DK-12. The sequence of green siltstone, carbonate, then anhydrite in a normal, upright minor cycle forms a major synform succession. Examination of the core from these drillholes confirms these are major synforms and probably are the upper Windsor Group, C1 Limestone. Dips are steep (65-75°) and the true stratigraphic thickness is approximately 75 m. Stratigraphically correlative units are represented in the adjacent drillholes (e.g. DK-11 and DK-8, with multiple fold repeats probable). Drillhole DK-11 has an overturned section of three carbonate/anhydrite/salt minor cycles, inferred to be the C1 Limestone. Synform/antiform folds repeat part of the stratigraphic section 3 times with

a synform at 2860 feet (872 m) and an antiform at 3340 feet (1018 m).

A similar succession with the C3 Limestone occurs in the transect that includes the KBW No. 1 brine well. Here, DK-3 has a major antiform sequence and lithology typical of the C3 Limestone at a depth of 1800-2620 feet (550-800 m). The fold axis is inferred at a depth of approximately 2250 feet (686 m) and two mirror image intersections of the C3 Limestone occur upright at 1820-1960 feet (555-597 m) and overturned at 2420-2620 feet (738-800 m). An upright section through the C3 Limestone occurs in DK-9 at 2120-2180 feet (646-665 m). Although the drill core is not available, a lithologically similar section occurs in KBW No. 1 at 2470-2560 feet (753-780 m) in an upright orientation. KBW No. 1 and DK-9 are only 38 m apart, although the 70° dips produce an intersection depth difference of approximately 100 m. The dips are very steep (70-85°) and thus the >1200 m deep drillholes may contain as little as a 300-500 m (or less if fold repeated) of stratigraphic section, and consequently only a hundred metres (stratigraphic thickness) of salt. The lithology in DK-4 is very similar to the lower part of the Mabou Group, with saline evaporite facies and fine-grained mudrocks (marine carbonates absent) immediately above the Windsor Group. DK-4 is dominated by grey with minor red lacustrine mudrocks typical of the Hastings Formation. DK-4 and nearby drillhole DK-3 were sampled and submitted for palynological dating to Dr. John Utting, Geological Survey of Canada, Calgary, to confirm age, and identify thermal maturity and stratigraphic correlation. All samples were determined by Utting, in a preliminary report, to have a high level of thermal maturity with Thermal Alteration Index of 3+ to 4, equivalent to vitrinite reflectance of Ro 1.7 to 2.6%. Age determinations based upon the identifiable taxa were consequently limited and indicate the sections sampled were not older than the Lower Windsor Group (Utting, written communication, 2001).

In general, the Domtar drilling appears to represent the upper Windsor Group (Major Cycles 3 to 5; Giles, 1981) to lower Mabou Group (Hastings Formation), but may not reach the sections of Major Cycle 2 (B subzone) or Major Cycle 1 (A subzone of the Lower Windsor). The complete composite stratigraphic section of correlative Major Cycles 2 to 5 in the Malagawatch and McIntyre Lake areas (Giles 2001) is approximately 470 m thick and comprises 36% salt. Major Cycles 1 and 2, with stratigraphic thickness of 400 m and 530 m, are generally the most saline of the Windsor Group in the area, with 40% and 55% salt and minor potash. These may be prospective units at deeper levels at Kingsville or elsewhere in the area. The depth to the bottom of the saline Windsor Group may be considerable based on extrapolation from the existing drilled stratigraphy and structure. It may be interrupted, however, by a major structural break and consequent section truncation (e.g. the Ainslie Detachment at the top of the basal anhydrite, possible decollement/thrust). Stratigraphic and structural comparisons with the McIntyre Lake and Port Richmond salt deposits, as well as the Orangedale and Malagawatch salt and potash deposits (Giles, 2001), will be investigated.

Salt Geochemistry

Although salt springs have not been reported from the Kingsville area, several were reported by Hayes (1931) to occur near Whycocomagh, 20 km to the north, and West Bay, 12 km to the east. The presence of these salt springs indicates that salt probably underlies a large part of the River Denys lowland valley area. Domtar Inc. (1978) reported four main categories of salt grade: (1) very high grade, greater than 95% NaCl; (2) high grade, 90-95% NaCl; (3) medium grade, 75-90% NaCl; and (4) low grade, 60-75% NaCl. Potash salts are not reported in significant amounts in any of the drillhole logs or analyses. Domtar Inc. (1978) described notable intersections of very high and high grade salt in drillholes DK-5, DK-6, DK-7 and DK-9 (Table 1).

The salt analytical database on approximately 10,000 salt samples provided by Domtar Inc. (1978) is the largest available for any salt deposit in the province. The Domtar Inc. (1978) analytical data are included in a digital compilation by Boehner (2002). The success of the brining test (KBW No. 1), and the deposit description by Domtar Inc. (1978), indicates that salt grades and

Table 1. Very high-grade salt intersections, Kingsville deposit. Note all depths and intervals are in feet (after Domtar Inc., 1978).

Hole No.	Intervals	Apparent Thickness	NaCl Grade %
DK-5	2620-2687	67	95.55
DK-5	3024-3086	62	97.39
DK-6	2325.1-2497.5	172.4	96.4
DK-6	2721.7-2847.6	125.9	95.17
DK-6	2976-3169.1	193.1	95.82
DK-6	3278-3600.3	322.3	96.22
DK-7	1968-2293	325	97.64
DK-7	2342-2569.7	227.7	97.54
DK-7	3008.3-3198.5	190.2	97.13
DK-7	3410-3552	142	96.82
DK-7	3588-3648	60.7	96
DK-9	1302-1598	296	97

tonnages would be sufficient for economic extraction.

Economic Considerations

The Kingsville deposit comprises halite with no significant intersections of potash reported. It is defined by 11 drillholes and coincides with a high amplitude Bouguer gravity low extending over a length of more than 4000 m. Domtar Ltd. (1968) reported proven salt reserves, based on the drilling data, of approximately 28.6 million t (31.5 million tons). Domtar Inc. (1978) estimated probable reserves adjacent to the drilled area of approximately 1.04 billion t (1.15 billion tons), based on a 40% salt extraction ratio. Domtar Inc. (1978) has also considered the deposit for possible development of an underground salt cavern for petroleum storage. The Kingsville deposit is well suited for this use because it is situated approximately 20 km north of the ice free, deep water port facilities on the Strait of Canso. Currently, there is renewed interest in part of the deposit for underground storage use.

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Status Report on the Scientific Case for Designation of Joggins as a UNESCO World Heritage Site

J. H. Calder

Introduction

The long-celebrated cliff section at Joggins (NTS 21H/09), Nova Scotia, has the potential to become Maritime Canada's first natural World Heritage Site and only the eighth fossil site world wide, but the scientific case presented must be skilfully argued. Late in 2001, a Scientific Subcommittee was formed to oversee and further develop a strategy in building the case for Joggins. The Scientific Subcommittee reports through the Chair to a broad-based Steering Committee concerned with issues of site management, infrastructure development and community. The importance of these issues notwithstanding, UNESCO (1996) describes scientific justification as "the most crucial aspect of the whole nomination dossier" that must be submitted. The subcommittee must present irrefutable evidence that Joggins represents a natural site of "outstanding universal value" representing a major stage in the history of life, specifically, the Upper Carboniferous 'Coal Age' wetlands of Euramerica.

The Scientific Subcommittee presently comprises: John Calder (Chair: NSDNR), Kenneth Adams (Fundy Geological Museum), Howard Falcon-Lang and Martin Gibling (Dalhousie University), Deborah Skilliter (Nova Scotia Museum) and Graham Williams (GSC Atlantic). The participation of key vertebrate paleontologists is being sought. During the summer of 2001, Dalhousie University graduate student Heidi MacDonald carried out background research, described below.

The Proposed Case

The case being developed by the Scientific Subcommittee is built upon the following pillars.

The site itself. Although largely taken for granted by those familiar with Joggins, the coastal cliff section is a dramatic yet accessible site, hewn and replenished by the world's highest tides. Coastal erosion in this dynamic setting virtually guarantees the prospects for ongoing discovery, which is one of the criteria for judgement established by UNESCO (United Nations Educational, Scientific and Cultural Organization) and the IUCN (the World Conservation Union).

The fossil record. The fossil record of Joggins, collated by the author over past years, confirms that Joggins indeed records an entire ecosystem, with equal vertebrate, invertebrate and floral records, satisfying requirements of biodiversity, evolutionary innovation, community and uniqueness (Tables 1 and 2). Nowhere is there found a more complete record of the terrestrial Coal Age environment. Crowning this record, Joggins can continue to claim the appearance in the fossil record of the earliest reptile, *Hylonomus lyelli* (Fig. 1), now that the older tetrapod *Westlothiana lizzae* from the Viséan of Scotland is considered to be a more primitive stem amniote (Ahlberg and Milner, 1994; Carroll, 1992; A. R. Milner, personal communication, 1999). The famous, unusual tree stump fauna of Joggins (Benton, 2000) contributes to the rich record of terrestrial Coal Age life seldom preserved in the fossil record elsewhere (Carroll *et al.*, 1972; Carroll, 1994; Milner, 1987).

The sedimentary record. "But the finest example in the world of a natural exposure in a continuous section ten miles long, occurs in the sea cliffs bordering a branch of the Bay of Fundy in Nova Scotia." So wrote Sir Charles Lyell in his discussion of the Carboniferous coal measures in *Elements of Geology* (1871). We contend that Joggins is indeed the world's best exposed

Table 1. Criteria for the evaluation of palaeontological sites nominated for inscription on the World Heritage list (Thorsell, 1994).

Question 1:	Does the site provide fossils which cover an extended period of geological time? i.e. how wide is the geological window?
Question 2:	Does the site provide specimens of a limited number of species or whole biotic assemblages? i.e. how rich is the site in species diversity?
Question 3:	How unique is the site in yielding fossil specimens for that particular period of geological time? i.e. would this be the type locality for study or are there similar areas that are alternatives?
Question 4:	Are there comparable sites elsewhere that contribute to the understanding of the total "story" of that point in time/space? i.e. is a single site nomination sufficient or should a serial nomination be considered?
Question 5:	Is this site the only or main location where major scientific advances were (or are being) made that have made a substantial contribution to the understanding of life on earth?
Question 6:	What are the prospects for on-going discoveries at the site?
Question 7:	How international is the level of interest in the site?
Question 8:	Are there features of natural value (e.g. scenery, landform, vegetation) associated with the site? i.e. does there exist in the adjacent area modern geological or biological processes that relate to the fossil resource?
Question 9:	What is the state of preservation of specimens yielded from the site?
Question 10:	Do the fossils yielded provide an understanding of the conservation status of contemporary taxa and/or communities? i.e. how relevant is the site in documenting the consequences to modern biota of gradual change through time?

continuous succession of Carboniferous coal measures (Fig. 2). The dramatic rock record, significant in its own right, is especially important in providing environmental context to the fossil record, including fossil forests (Fig. 3). This contextual framework is lost in most fossil Lagerstätten (exceptionally well-preserved biotas of whole fossils), wherein the terrestrial record comprises transported accumulations rather than an *in situ* record, as at Joggins. An important aspect of the paleontological record at Joggins emerging from current research is the history of climate change, with periodic dryland conditions that contrast with the better known wetland landscape of the paleoequatorial 'Coal Age'.

The history of science. Lyell's enthusiasm for Joggins is a matter of historic record (Lyell, 1845, and later letters), not only because it yielded important new discoveries of the history of life on earth, but Joggins was a proving ground for his *Principles of Geology*. Sir Charles Darwin himself drew upon the discourse of the Joggins section by Lyell (1843 and others) and Dawson (1845, 1855) in developing the case for his theory of evolution in *Origin of Species*. For both Lyell and Darwin, Joggins served as their 'Coal Age Galapagos'. To these impressive credentials can be added the pioneering role played by fossil discoveries at Joggins in our understanding of the history of life.

Complementary Arguments

The depth of the case for the inscription of Joggins on the World Heritage list is compelling. Complementing the four major 'pillars' described above are the following, which contribute to the justification of Joggins.

Cultural history: Joggins has been the site of coal mining since the early Seventeenth Century, when its coal was used to fuel the fires of the first French settlement at Port Royal, a history spanning four centuries. Vestiges of a thriving export

Table 2. Recommendations of Wells (1996) for evaluation of fossil sites nominated as prospective World Heritage Sites.

Recommendation 1:	Choose sites that contain well-preserved fossil accumulations of high species diversity which in combination best document the story and environmental change through time;
Recommendation 2:	The 'events' to be represented in the history of life should, where possible, encompass the iconography of a tree of life not a ladder of progress;
Recommendation 3:	Choose fossil Lagerstätten and make provision for expanding the list or substituting sites/fossils to better tell any chapter of the story;
Recommendation 4:	Separate Precambrian history from Phanerozoic history (the roots from the upper branches of the evolutionary tree respectively), Present Precambrian history as major events, such as the origin of life, multi cellularity, etc., and Present Phanerozoic history in terms of communities and/or stages in the evolution of major groups;
Recommendation 5:	All published Precambrian fossil sites should be reviewed by an expert panel to select those worthy of evaluation for Heritage listing;
Recommendation 6:	Phanerozoic sites should be chosen so as to be representative in time and space of both community structure and selected phylogenetic lineages;
Recommendation 7:	Any fossil Lagerstätten chosen from the Phanerozoic should wherever possible be of high diversity and include significant invertebrate as well as vertebrate assemblages;
Recommendation 8:	A condition for granting World Heritage status should make provision for curation, study and display of any site/fossils;
Recommendation 9:	Specialists in the major Phanerozoic groups and time periods should be consulted to refine and update the indicative list.

industry to the eastern United States during the Eighteenth and Nineteenth Centuries can still be found at Lower Cove, where millstone and grindstone quarries once operated, and where huge millstones lie exposed at low tide between the resistant sandstone ridges ("reefs") of the intertidal zone.

Significance to ongoing research and education: Joggins remains the site of innovative geological research and discovery, documented in benchmark journal manuscripts in preparation by international scientific teams. The section is a required stop on field trips by scientific groups, and is regularly visited by local and international universities and schools.

Historical recognition: This celebrated section has been an international field trip destination (Fig. 4) since the visits of Sir Charles Lyell in 1842. That same year, Joggins became the subject of the first field project of the Geological Survey of Canada, led by Sir William Logan.

International interest: Records of the Joggins Fossil Centre indicate that the cliffs have been sought out in recent years by visitors from at least 44 countries, this even before inscription and significant infrastructure development. The section has been the subject of international research, as witnessed by the scientific bibliography, and its fossil record is featured in the majority of textbooks on vertebrate paleontology and the history of life. Joggins fossils, including type specimens, reside in world museum collections including those of the British Museum of Natural History, Harvard, McGill and Yale.

Although not part of the Carboniferous story, Joggins also exposes a classic multiple till section recording Quaternary glaciations. The till section recently was brought into prominence on the cover of Special Publication No. 185 of the Geological Society of London, *Drift Exploration in Areas of Glaciated Terrain*, photographed by R. R. Stea of NSDNR.

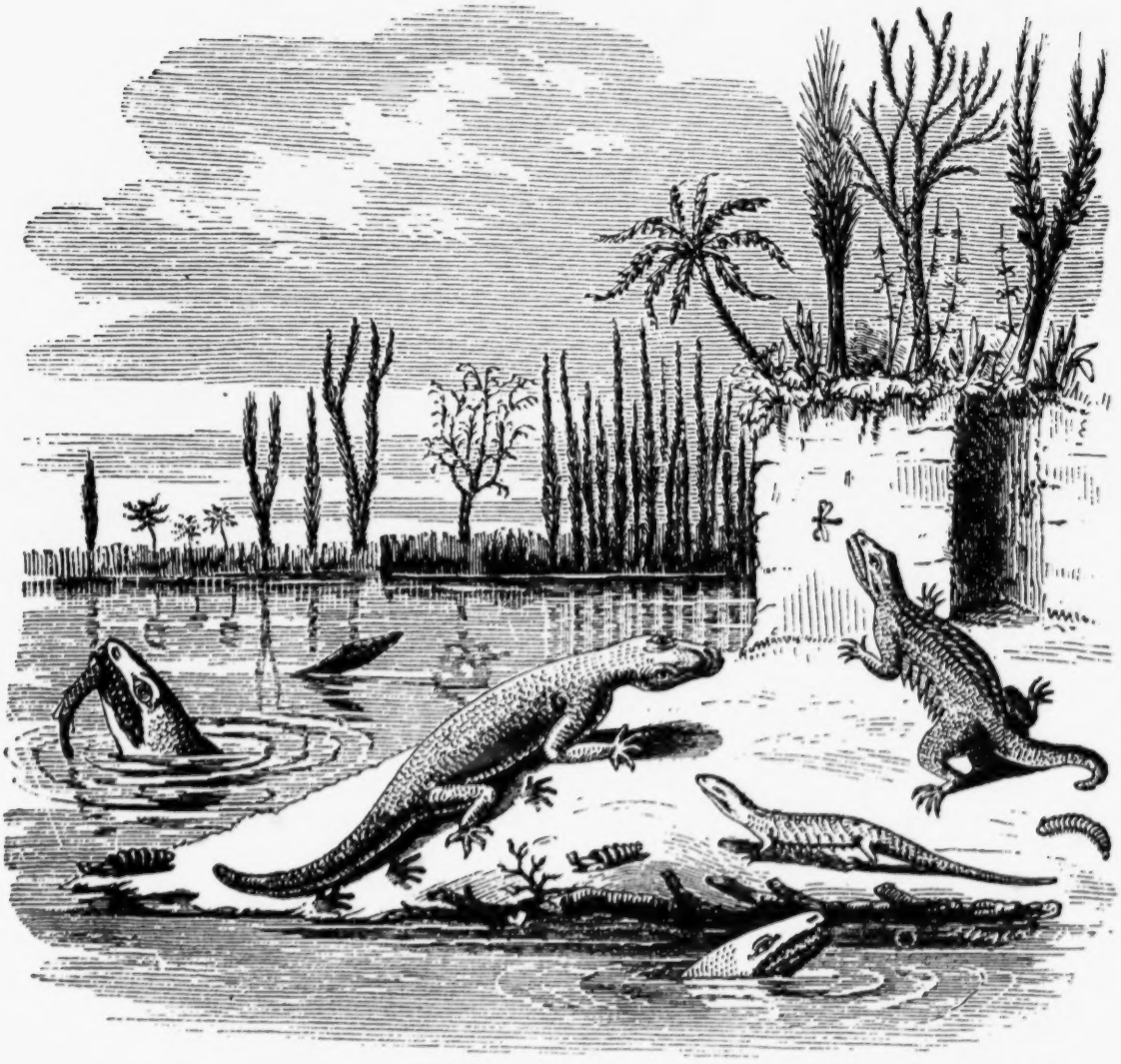

Figure 1. Dawson's (1863) early reconstruction of life at Joggins, which included the earliest known reptile, *Hylonomus lyelli*.

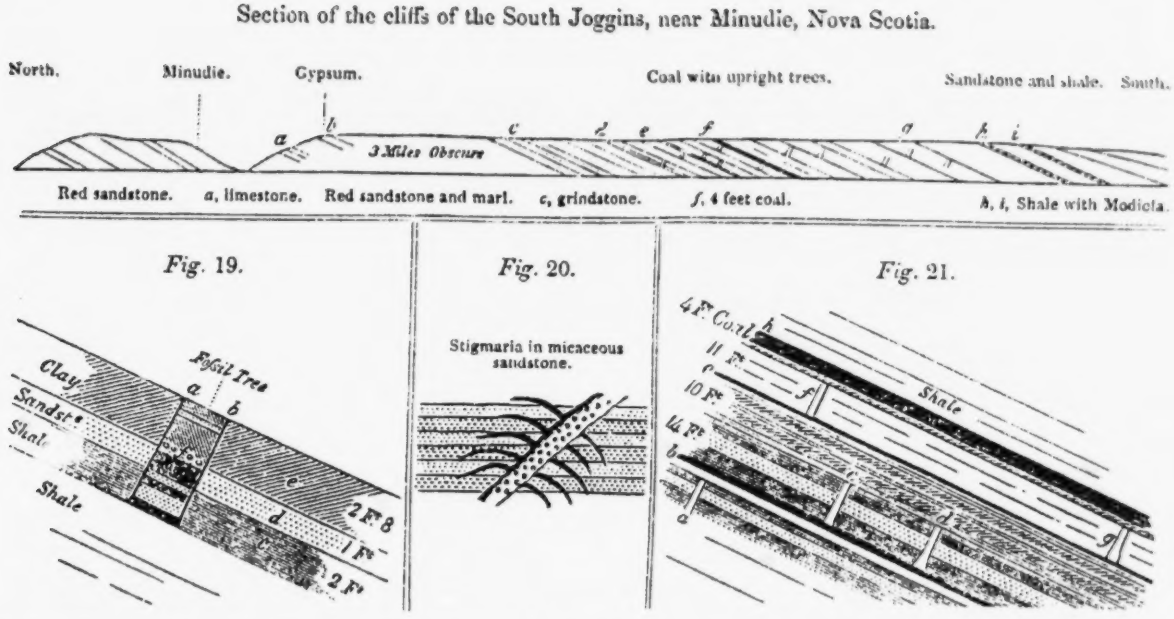

Figure 2. The classic stratigraphic succession exposed at Joggins, with details of the standing fossil trees, as figured by Sir Charles Lyell (1845).

Projects and Their Status

Individual projects fulfill specified requirements of UNESCO. Projects required in the nomination format guidelines include:

- compilation of the floral and faunal record of biodiversity;
- type specimens and collections from Joggins housed in world museums;
- atlas of specimens and features; and
- scientific bibliography.

Chief among required and recommended projects is a comparative study to confirm Joggins's standing amongst contemporary world sites. During the upcoming year (2002), the Scientific Subcommittee will enlist international scientific authorities from outside Canada to co-author the study. Background research of possible competing sites was undertaken during the past year by Heidi MacDonald and the author.

Specific projects are being planned and carried out to strengthen strategic aspects of the case. Many of these take the form of journal manuscripts in preparation by members of the Scientific Subcommittee and others. Section logs for the entire Joggins Formation, spanning 2 km of section from Lower Cove to MacCarrens Creek, have been compiled by Sarah Davies (Leicester University), Martin Gibling (Dalhousie University) and the author. These logs have been recorded graphically in the field at a scale of 1:100 and digitally transcribed by Andrew Henry in the past year under contact to the Cumberland Regional Economic Development Association (CREDA). The section logs represent the first bed-by-bed description since Logan (1845), and will provide an important contextual framework for future research and collection at the site.

Conclusions

As of December 2001, only seven fossil sites worldwide have been recognized as natural World Heritage Sites. Recently successful cases for the Devonian site at Miguasha, Gaspé, inscribed on the World Heritage list in December 2000, and the Mesozoic section of the Dorset Coast, UK, in December 2001, provide useful points of comparison in developing the case for Joggins. In June 2002, a working visit to Parc de Miguasha is planned by the Steering Committee.

Figure 3. An erect fossil lycopsid tree of the Joggins Formation, entombed in growth position.

Ultimately, the case for scientific justification will be presented by Canada to the World Conservation Union (IUCN), the body designated by UNESCO to evaluate natural sites. A timeline for projects is currently being evaluated by the Scientific Subcommittee, but it is hoped that the bulk of the justification dossier will be in hand within two years. Although not explicit in the UNESCO and IUCN guidelines, it is clearly implied that sites that represent certain periods of Earth history are favoured, and time is of the essence if Joggins is to be the first, and possibly only, site considered for the Carboniferous 'Coal Age'.

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Figure 4. Delegates to the International Geological Congress of 1913 at lunch on their field trip to the coastal section at Joggins. The locality of the photograph is in the vicinity of the Fundy Seam (GSC photograph 24289).

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Cape Breton Island Mineral Inventory Studies: A Sandstone Quarry Development Opportunity at Graham River (NTS 11F/14), Inverness County

G. J. DeMont and J. E. Hawken

Compilation and revision of database records for mineral occurrences found on Cape Breton Island continued during 2001. In total, 38 new mineral occurrence records, 3 metallic and 35 industrial, were added to the Mineral Occurrence Database. These include record numbers:

F10-028 to F10-030, F11-026 to F11-041, F13-012, F14-074 to F14-090, F15-050.

In addition, 20 mineral occurrence records, primarily gypsum occurrences which had previously been entered as partial records, were given substantive updates.

Mineral inventory studies for the year focused on NTS map areas 11F/14 and 11F/11, which constitute the principal study area for the Targeted Geoscience Initiative (TGI), a joint federal-provincial geoscience mapping project. Completion of a mineral inventory compilation for these two map areas is one of the project components that the province agreed to provide as part of this initiative. At the beginning of the TGI project most of the metallic mineral occurrence records in the Mineral Occurrence Database were already up to date, but the industrial mineral compilation was only partially complete. As a result, industrial mineral occurrences are the focus of the inventory studies and database entries completed in 2001.

Most of the new mineral occurrence records listed above were compiled from Goudge (1934) and Shea and Murray (1970), but a few, particularly the metallic mineral occurrence records, were compiled from Nova Scotia Department of Natural Resources Assessment Reports.

Twenty mineral occurrence sites were field checked during the fall of 2001, and the field data collected are presently being compiled and added to the Mineral Occurrence Database. In addition to the site visits, two short diamond-drill holes were drilled to test an aeromagnetic anomaly located in the Ashfield area of Inverness County. The drilling indicated the source of this anomaly to be a magnetite-bearing basalt flow.

One of the mineral occurrences visited this year, database record No. F14-091, Graham River Sandstone Prospect (Fig. 1), may have significant potential for development of a sandstone quarry for the following reasons:

(1) Recent global public interest in the construction of healthy homes and ongoing restorations of stone heritage buildings in the north-east American states is producing an upswing in the markets for natural stone.

(2) An examination was made by the author this year of the Judique church manse foundation because Parks (1912) stated that it was built from sandstone extracted from the Graham River site (see Figs. 1 and 2) in the late 1880s. The sandstone blocks used in this foundation exhibit no signs of wear after more than a century of exposure.

(3) The prospect has good access to an excellent transportation infrastructure. It is located approximately 3 km east of Route 19 and 30 km from deep water shipping facilities at Port Hawkesbury.

(4) The sandstone is exposed in an area of steep topographic relief where a quarry face could be easily established.

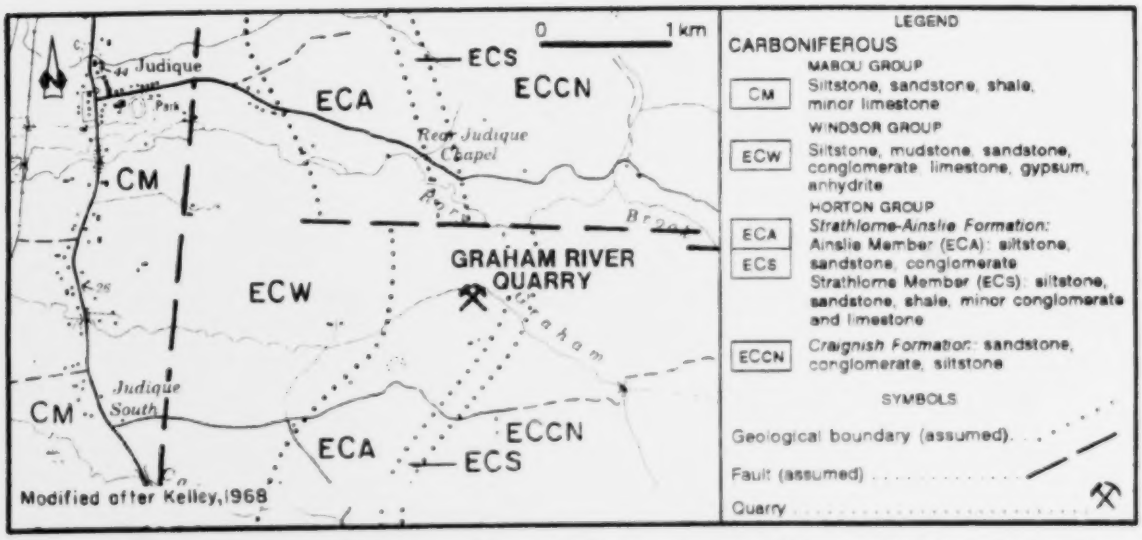

Figure 1. Geological map showing the location map of the Graham River sandstone prospect, Inverness County (11F/14). Figure from Dickie (1996).

Description of the Graham River Sandstone Prospect

History

Fletcher first made note of a red and grey sandstone quarry at Graham River on his geological map (1884) and described it briefly in his report (1881). He noted that sandstone was extracted from this site for local use.

Parks (1912) undertook a more detailed evaluation of the site for his Canada Department of Mines report on the building and ornamental stones of Canada. In his text he stated that no real quarry existed here, but he also noted that stone was produced from loose blocks found along the walls of a ravine. The stone was used for constructing the foundation for the presbytery building in Judique. Several tests were conducted on sandstone samples to determine the physical and chemical properties of the stone. He concluded that the physical properties of this stone are of a high order, and in particular, the coefficient of saturation was considered remarkable, the best in the Maritime Provinces. He also suggested that sandstone beds found at this site were capable of producing large blocks.

G. Dickie (1996) studied this site for his report on building stone in Nova Scotia. Part of his study included drilling a short diamond-drill hole to test the lateral extent of the sandstone deposit. This hole intersected 13.4 m of shale, but no sandstone. He concluded that (1) the sandstone was too jointed to produce large blocks, and (2) that the areal extent of the sandstone beds was limited by the shale bed intersected by the drill hole.

Regional Geology

The sandstone is part of a large, north-trending block of Carboniferous Horton Group strata extending north from St. Georges Bay to Southwest Mabou River. The south end of the block is truncated by a northeast-trending fault and the north end is truncated by a northwest-trending fault.

The sandstone was mapped by Kelley (1968) and Lynch and Brisson (1994) as part of the Ainslie Formation, a subunit of the Horton Group. This formation is characterized by fine-grained grey-green and pale reddish-grey sandstone separated by red-brown siltstone representing a range of fluviatile environments (Lynch and Brisson, 1994). The sandstone is typically quartz rich.

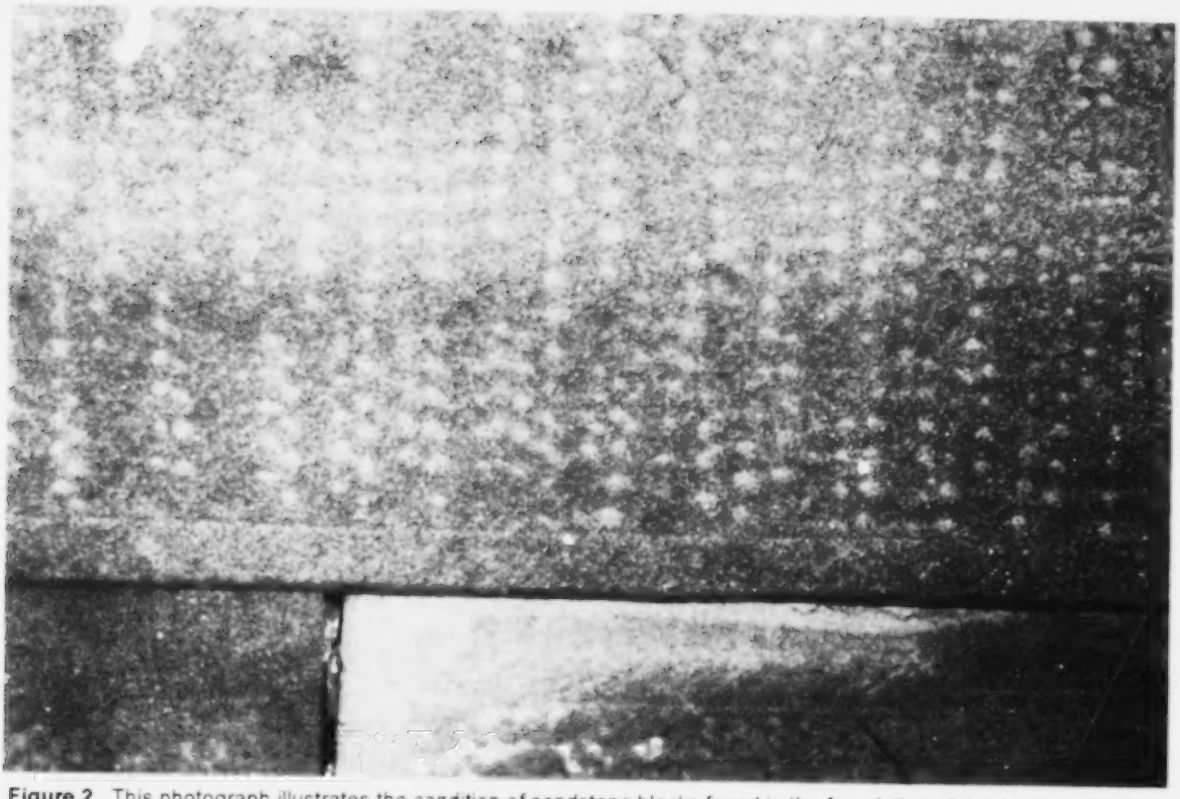

Figure 2. This photograph illustrates the condition of sandstone blocks found in the foundation of the Judique Manse. Note how the chisel marks (round spots) made when the stone was cut over a century ago are still evident.

The Ainslie Formation is conformably underlain by grey siltstone, shale and limestone of the Strathlorne Formation, which are in turn underlain by coarse sandstone and conglomerate of the Craignish Formation, the basal most unit of the Horton Group. The Horton Group strata are bounded to the west by a thin band of marine limestone of the Macumber Formation, a subgroup of the Carboniferous Windsor Group which conformably overlies the Ainslie Formation.

Deposit Geology

Red and grey sandstones are exposed along the north and south banks of Graham River over a minimum distance of 500 m. The river flows roughly east-west, but the strike of the sandstone beds is roughly northeast-southwest, so the 500 m dimension is exaggerated and does not reflect the true bedding thickness of this stratigraphic section. The sandstone beds dip northwest at angles of 63°-86°. Outcrops are most prominent on the south bank of the river where the sandstone is exposed along a steep, north-facing hillside to a height of more than 20 m above the water level (Fig. 3).

A thick section of grey shale, marking the contact between the Ainslie and Strathlorne formations, is exposed along the south bank of the river, at the east end of the sandstone section. Assuming that the strike of the Strathlorne shale exposed along the river bank is constant, the sandstone sequence should extend at least 300 m south of the river bank before this shale unit is encountered. The sandstone section should also extend for a considerable distance north of the river.

Sandstone bed thicknesses are variable, but the brook bed exposures contain some massive beds which should produce blocks of greater than 1.5m in thickness. The principal joint pattern is

Figure 3. This is probably the site where blocks were removed to build house foundations in Judique. The bed thicknesses found at this site suggest that large blocks could be quarried here.

approximately perpendicular to the strike of bedding, so many of the outcrop faces are joint surfaces.

Thin interbeds of shale and siltstone are found at several locations within the sandstone section, one of which was cored by the Nova Scotia Department of Natural Resources drillhole. This drill core was examined as part of the 2001 mineral inventory site visit, at which time it became apparent that the hole was drilled parallel to the dip of a red shale/siltstone bed. As a result, the drillhole gives a false impression that a thick shale bed is located within the sandstone sequence, but if the hole had been drilled at right angles to the bedding strike direction, it could have provided a totally different, and most likely favourable, picture of the volume of sandstone available at this site.

Conclusions

The Graham River Sandstone Prospect is a potential development opportunity, but detailed geological mapping is required to ascertain the volume and quality of stone available. Parks (1912) also mentions that similar sandstone occurrences are found north of the Graham River site, on the hills behind the villages of Judique and Port Hood.

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Progress Report on Data Compilation, Surficial Mapping, Seismic Surveys and Drilling for the Targeted Geoscience Initiative Project in South-central Cape Breton Island[1]

M. Feetham, R. R. Stea and S. E. Pullan[2]

Introduction

Work continued throughout 2001 in south-central Cape Breton Island as part of the federal-provincial Targeted Geoscience Initiative (TGI). The area of study includes NTS map areas 11F/11 and 11F/14 (Fig. 1). Within this area are several large Quaternary depositional basins, which are underlain by Carboniferous bedrock and infilled with glacial sediments. The surficial component of this project will focus on the River Denys Basin, the River Inhabitants/Kingsville Basin, and the Moran and Hawthorne basins (Fig. 2).

Prior to the TGI project, the structural nature and origin of these basins was largely unknown. New 3-dimensional stratigraphic models created as part of this project will provide additional data to define the structural history of these basins, and may also provide information for new mineral exploration targets. Preliminary results from seismic surveys and drilling completed in 2000 and 2001, indicate that these basins are complex fault-bounded blocks rather than simple glaciated valleys.

Fine-grained, massive clay deposits occur in several locations in the study area. These clays were deposited in glacial lakes present in the area ca. 11-10 ka (Stea *et al.*, 2002). Work to evaluate the potential of these clays for earthenware applications is currently being conducted.

Data Compilation

Throughout past decades, a multitude of mineral exploration data has been collected in south-central Cape Breton Island by private industry as well as government. Until now these data have not been compiled to create a comprehensive geological database. Both surficial and bedrock data are presently being compiled in a GIS format using ArcView® software. Key sources of data include the Department of Environment and Labour water well database, NSDNR drillhole database (containing industry and government drillhole data), geotechnical drill logs from the Department of Transportation and Public Works, drillhole databases from Georgia Pacific Canada Inc., and numerous bedrock geology maps. Current surficial mapping (R. R. Stea), seismic surveys (S. E. Pullan, Geological Survey of Canada), and drilling will supply new information on the basins.

Field Work

Much of the 2001 summer field season was spent determining accurate locations for residential water wells using a hand-held Global Positioning System (GPS) unit. Approximately 364 water wells were located for NTS map areas 11F/11 and 11F/14 (Fig. 3). Depth to bedrock and type of surficial material are recorded in each well log in the Department of the Environment and Labour database. This information is an extremely useful

[1]Contribution to the Targeted Geoscience Initiative project: Geological Mapping for Mineral Development in South-central Cape Breton Island. Funded by Natural Resources Canada and the Nova Scotia Department of Natural Resources

[2]Geological Survey of Canada, Terrain Sciences Division, 601 Booth Street, Ottawa, Ontario K1A 0E8

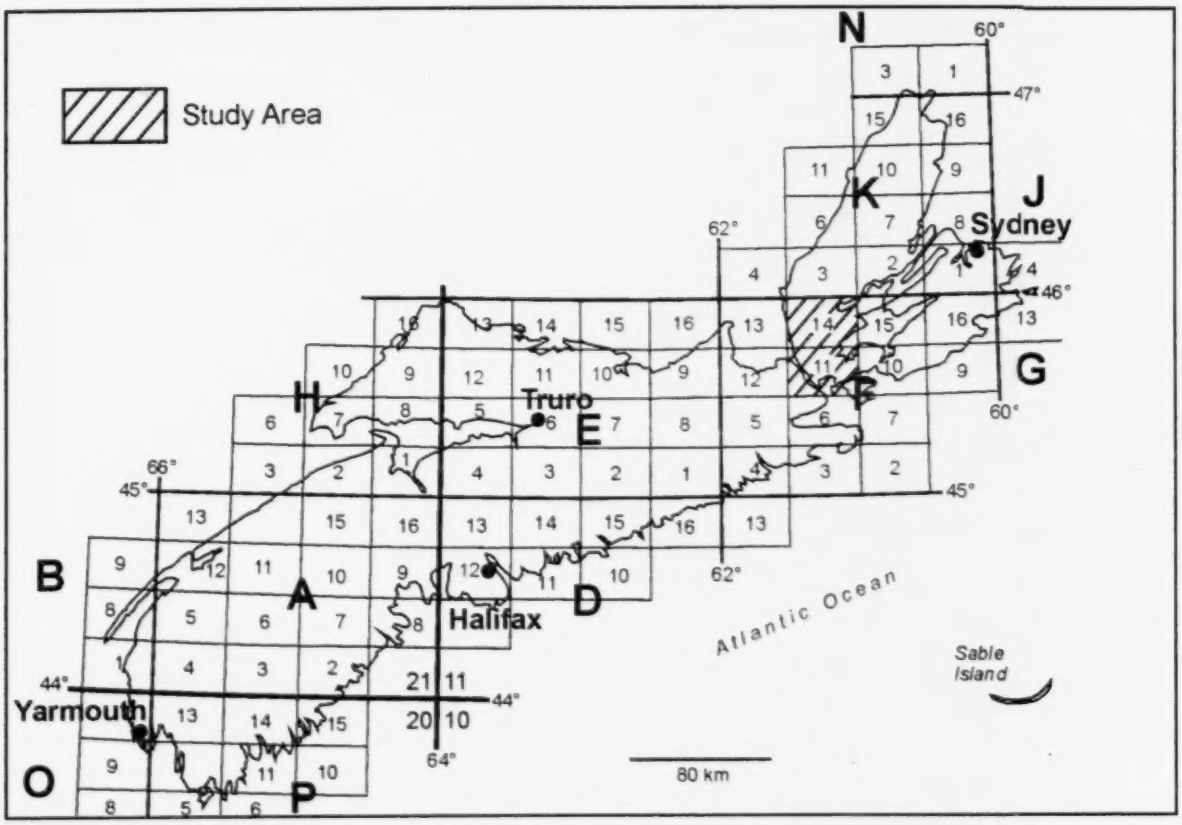

Figure 1. Map of Nova Scotia showing location of the study area.

and inexpensive tool in obtaining data for large parts of the study area. The well logs and the location data have been incorporated in the TGI database, which can be viewed in ArcView®.

Work was also conducted to delineate and collect bulk samples of the previously unknown earthenware clay deposits (R. R. Stea *et al.*, this volume) in the western part of map areas 11F/11 and 11F/14. Field work also included assisting with seismic surveys conducted by the S. E. Pullan of the Geological Survey of Canada.

Seismic Surveys

Shallow seismic reflection testing was conducted in the fall of 2000 and the summer of 2001 to assist in identifying areas of deep surficial cover and provide approximate depths to bedrock. Methods are described in Pullan *et al.*, (2001) and Stea *et al.*, (this volume). Areas tested included locations where previous drillhole information indicated thick, unconsolidated sediments as well as sites where information was limited. A total of 139 test spreads were run over the entire study area, followed by a detailed seismic survey across the River Denys Basin in September 2001 (Fig. 4). These data are presently being incorporated into the GIS database.

Drilling

Introduction

Based on the compiled data, drill targets were established in three basins. These include the River Denys Basin, the River Inhabitants/Kingsville Basin and the Moran and Hawthorne basins (Fig. 2). Drilling was designed to gain specific information on the surficial and underlying bedrock

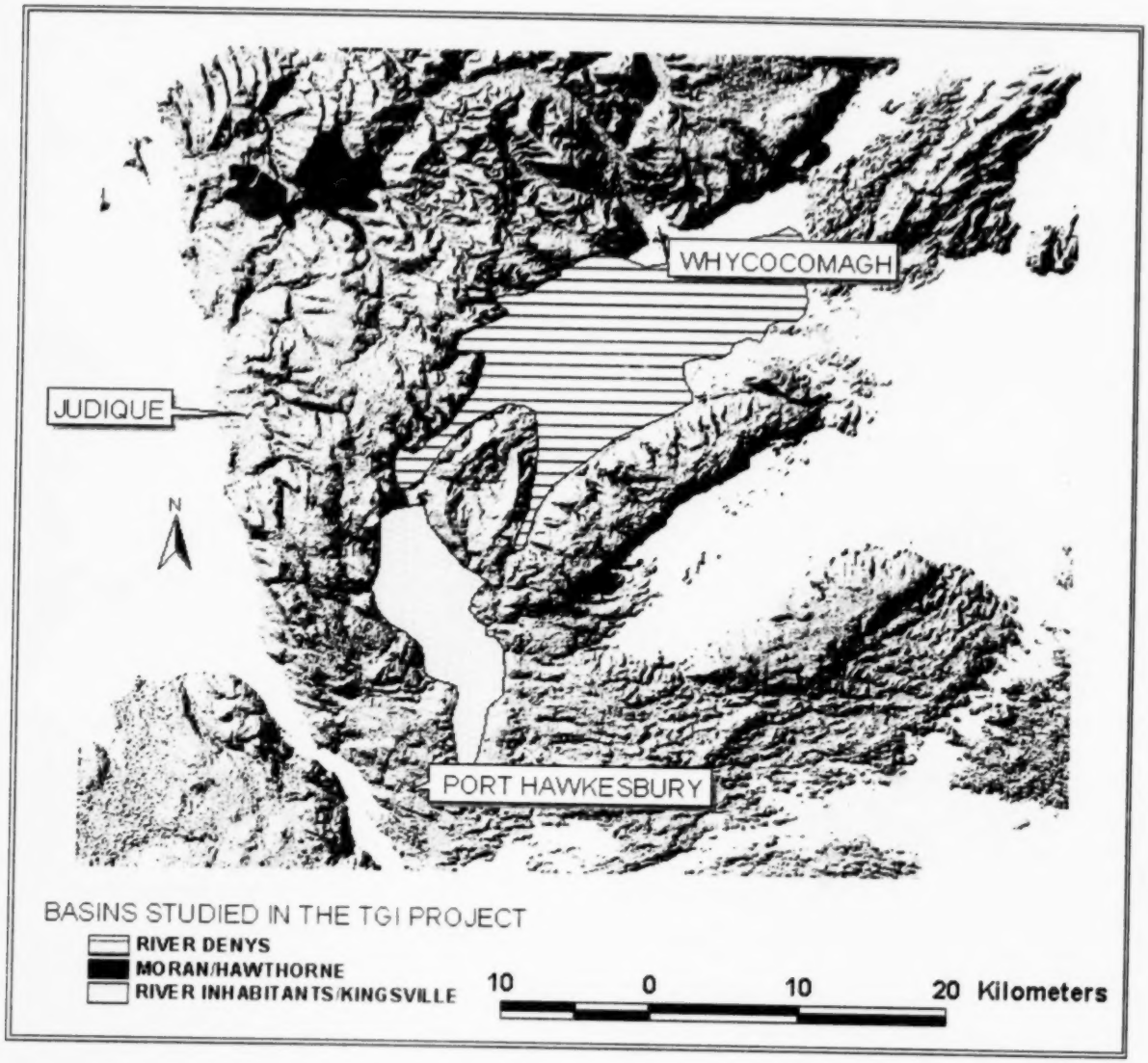

Figure 2. Location of the basins studied for the Targeted Geoscience Initiative project.

geology of these areas. Targets were established for several reasons: (1) to verify data from seismic surveys, (2) to confirm suspected faults within or at the edges of the basins, (3) to search for hidden Cretaceous sand and clay, and (4) to further delineate the earthenware clay deposits in the Moran/Hawthorne basins. Two additional drillholes were planned to test a magnetic anomaly in the Ashfield area. The first phase of drilling was conducted in March 2001, followed by a longer program in November and December 2001. Results from drilling will be used to build cross-sections and 3-dimensional models for each of the basins.

Methods

For the first phase of drilling (March 2001) a large track-mounted drill equipped with a wire line

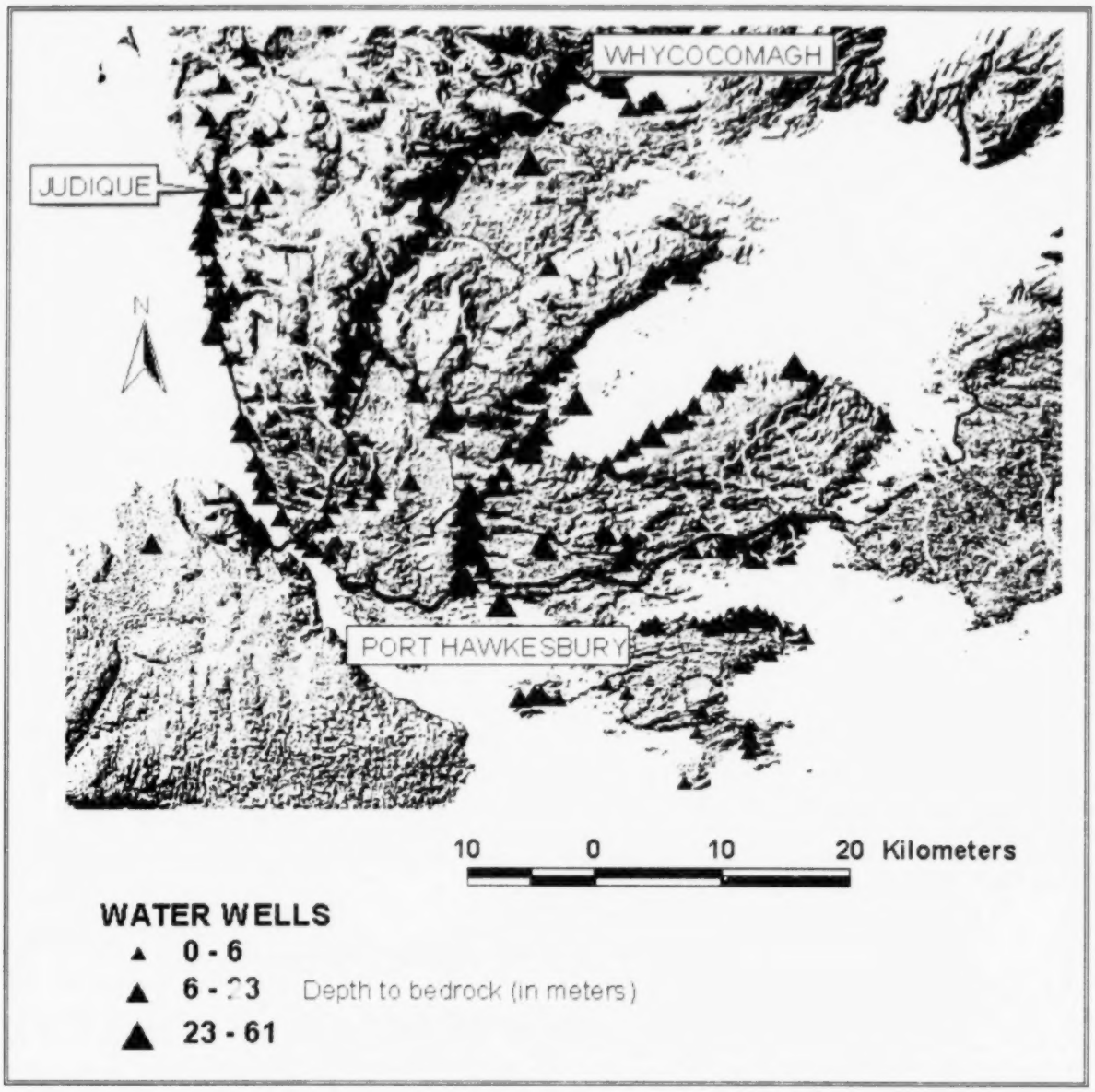

Figure 3. Locations of water wells presented in ArcView®.

coring system was used. It was designed to give high recovery in unconsolidated sand and clay, and was extremely mobile. Materials could be quickly triconed if core was not desired. Drilling in the fall of 2001 was conducted using a smaller, more versatile, track-mounted rotary drill. This multi-purpose drill allowed for a variety of sampling techniques, including augering, split spooning and coring. Standard augers with a 4.5 inch diameter could be used to quickly drill down through surface clay, sand and gravel. Grab samples could be taken at 5 foot intervals along each auger. Alternatively,

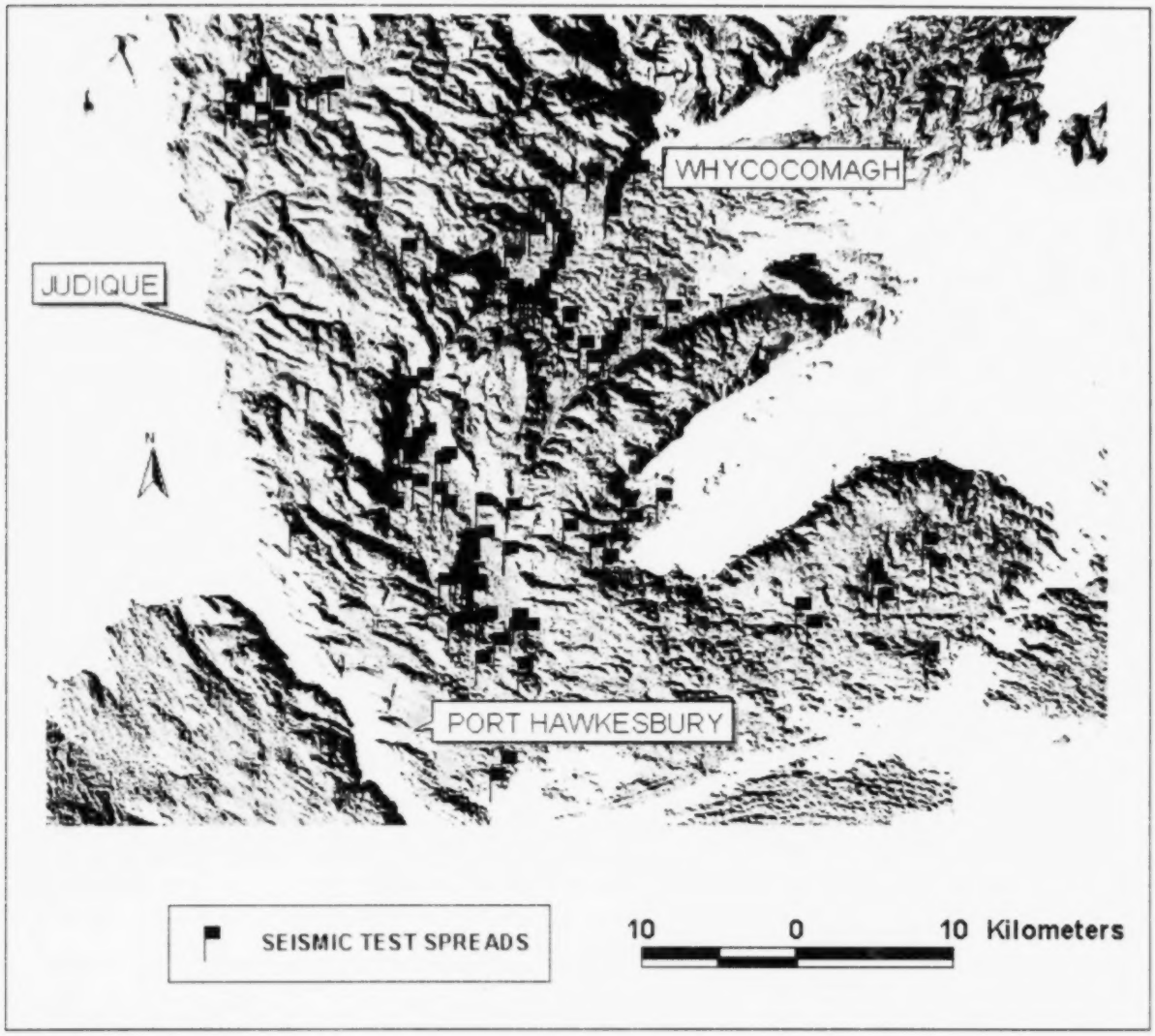

Figure 4. Map of study area showing locations of seismic test surveys.

a 1.5 inch diameter, 2 foot long split spoon sample could be obtained by driving a sampler ahead of the auger at the base of the hole. The drill was equipped with a 140 lb. hammer with a 30 inch drop. If ground conditions became unfavourable for auguring or split spooning, the drill could be switched over to diamond-drilling. Holes that were to be cored were cased with 3.9 inch HW steel pipe to keep holes from caving in. An HQ core barrel and rods were used to obtain a 2.5 inch core sample. All holes were drilled vertically, and the steel casing was removed when holes were completed. Several of the deeper holes were lined with a 3-inch PVC pipe for later (summer of 2002) geophysical logging.

Preliminary Results and Discussion

Twenty drillholes totalling 828 m were completed in the study area (Fig. 5). Results are listed in Table 1. Nine holes were cased for down-hole logging. The drilling results and stratigraphy of the

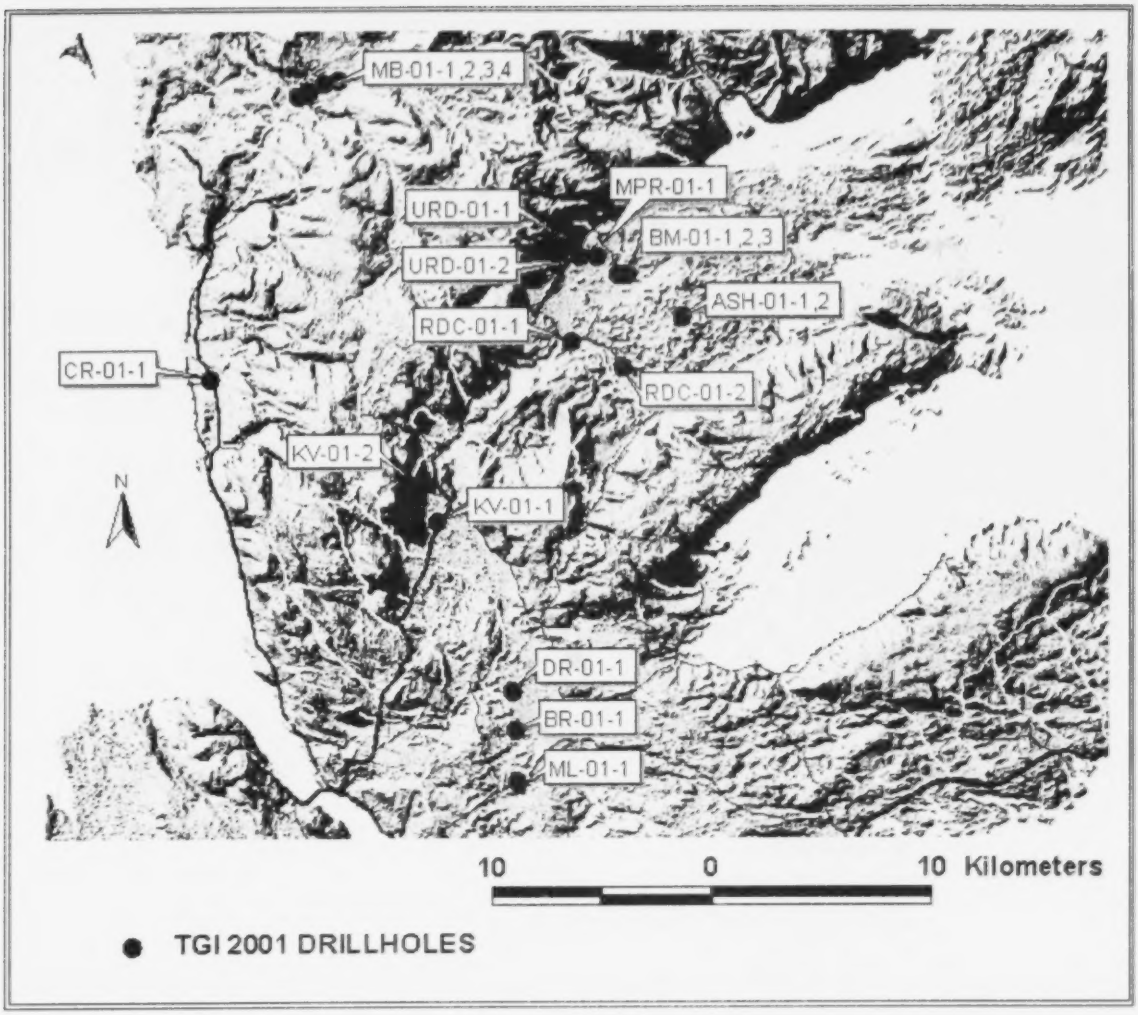

Figure 5. Location of TGI drillholes, 2001.

basins will be discussed by grouping the holes into their geographic areas (basins).

River Denys Basin

The River Denys Basin extends from the Creignish Hills eastwards to the North Mountain in the central part of map area 11F/11. Holes were drilled in the northwest part of the basin where surficial cover is the deepest, as well as at the western margin to test for faults and possible hidden Cretaceous outliers. Ten holes were drilled in the basin. This includes two holes drilled to test a magnetic anomaly in the Ashfield area, which will not be discussed in this report.

Drilling results indicate that surficial sediments are dominated by thick sequences of red-brown glaciolacustrine clay, silty clay and sand, with thinner intervals of till and coarse gravel overlying them. Underlying this package are alternating blue-grey and red-brown silty-sandy clays (interpreted as part of the Windsor Group) up to 20 m in thickness, which are commonly strongly deformed. In turn, these overlie Carboniferous limestone and/or gypsum.

Maximum depth to bedrock exceeds 79.2 m in hole URD-01-2 (Fig. 5), which was abandoned in sand due to caving. To the east, hole BM-01-3 was drilled along seismic line 4 to test for faulting

Table 1. Data from TGI drillholes.

DRILLHOLE	NORTHING	EASTING	T_DEPTH	D_T_BED (m)	DATE DRILLED	CASED
CR-01-1	5077499	617728	15.2	>15.2	DEC 2001	NO
MB-01-1	5093438	624555	15.2	13.7	DEC 2001	NO
MB-01-2	5093204	623763	34.7	30.5	DEC 2001	NO
MB-01-3	5092791	623056	18.3	>18.3	DEC 2001	NO
MB-01-4	5092564	622424	7.6	7.0	DEC 2001	NO
URD-01-1	5084565	636830	83.8	80.8	NOV 2001	YES
URD-01-2	5083995	637277	79.2	>79.2	NOV 2001	YES
RDC-01-1	5079447	636858	31.0	>31.0	MAR 2001	YES
RDC-01-2	5078151	639559	51.0	12.8	MAR 2001	YES
MPR-01-1	5084020	638213	60.9	59.1	DEC 2001	YES
BM-01-1	5083071	639359	94.5	92.2	MAR 2001	YES
BM-01-2	5083026	639685	60.9	54.8	DEC 2001	YES
BM-01-3	5083056	639854	21.3	20.2	DEC 2001	NO
ASH-01-1	5080806	642721	17.0	7.9	NOV 2001	NO
ASH-01-2	5080759	642699	30.0	8.2	NOV 2001	NO
KV-01-1	5069857	629747	30.5	30.0	NOV 2001	NO
KV-01-2	5071854	628479	88.4	>88.4	NOV 2001	YES
DR-01-1	5061012	633713	17.1	13.7	NOV 2001	NO
BR-01-1	5058947	633895	56.0	51.4	MAR 2001	YES
ML-01-1	5056195	633996	15.4	13.8	NOV 2001	NO
TOTAL (M)			828.0			

inferred by the seismic surveys. Bedrock is shallow, and a brecciated, altered limestone was intersected which verified the results of the seismic work.

River Inhabitants/Kingsville Basin

To the south, the River Inhabitants/Kingsville Basin is separated from the River Denys Basin by the Maple Brook Syncline. Five holes were drilled (Table 1) along the northwestern margin of the basin at the base of McIntyres Mountain, and to the south near Sugar Camp and McIntyres Lake.

Stratigraphy in the Kingsville area is similar to that of the River Denys Basin, characterized by a series of glaciolacustrine, red-brown massive clay, silty clay, and sand. The major difference is that in the Kingsville area the glaciolacustrine deposits occur near surface, overlying tills and gravel, thus indicating a younger age for the massive clay and sand compared to those in the River Denys Basin. This suggests changes in the location and timing of glacial ice, which must have been present to cause damming in order to deposit these thick sequences. As in the River Denys Basin, a blue-grey silty clay unit underlies these sediments; bedrock is grey siltstone containing gypsum veinlets.

Hole KV-01-2 (Fig. 5) intersected 12.2 m of red-brown earthenware clay similar to that found in western Cape Breton. Bulk sampling and testing will be required to evaluate the clay. Depth to bedrock is variable but generally deepest along the western margin of the basin adjacent to the Creignish Hills (>88.3 m).

To the south, (BR-01-1, ML-01-1, DR-01-1) the predominate lithologies are red-brown and grey-brown matrix-supported silty diamictons which are interbedded with minor clays and coarse gravels. This package of sediments is interpreted as till deposits. The glaciolacustrine massive clays, silty clays and sands common to the River Denys Basin and Kingsville areas are not evident here. Either they were not deposited or have subsequently been eroded. An interesting dark grey-black organic rich clay containing woody peat occurs at the base of BR-01-1 just above the gypsum bedrock contact. Depth to bedrock ranges from 13.7-51.4 m in the holes drilled in these locations.

Moran and Hawthorne Basins

Located in the northwestern part of map area 11F/14, theses two small basins are infilled with earthenware quality clay, (Stea *et al.*, this volume) sand and gravel. Four holes (MB-01-1, 2, 3, 4) were drilled in an east-west line across the Moran Basin to delineate the clay deposit, as well as to test the seismic survey data. Thicknesses of the high quality clay range from 3.6-16.7 m, most commonly occurring near surface. Bedrock is gypsum in hole MB-01-2 and -4, and dark grey micritic limestone in hole MB-01-1. Hole MB-01-3 was augered to a depth of 20 m and did not intersect bedrock.

One additional hole (CR-01-1) was drilled south of Judique along Centennial Road. This hole was augered to a depth of 16 m. It intersected red-brown matrix-supported silty diamicton (interpreted as till) and did not reach bedrock. No massive clay or sand was evident in this hole.

Summary of Work Completed

Most of the compilation work for the study area has been completed and data sets entered into the GIS database. Work in 2002-2003 will concentrate on interpreting the results from seismic surveys and new drilling. Preliminary results indicate a complex structural nature of the basins, as well as presenting hypotheses for timing and location of ice present in these localities during the last glaciation. Down-hole geophysical logging of the drillholes will be completed during 2002. Further sampling and testing of the earthenware clay deposits will also be done in the following year. All data will be made available for public access at the completion of the TGI project.

References

Pullan, S. E., Hunter, J. A., Burns, R., Douma, M. and Stea, R. R. 2000: Testing of shallow seismic reflection technique, Cape Breton Island (NTS 11F/10, 11F/11 and 11F/14); *in* Minerals and

Energy Branch, Report of Activities 2000; Nova Scotia Department of Natural Resources, Report ME 2001-1, p. 73-79.

Stea, R. R., Finck, P. W., Pullan, S. E. and Ostrom, W. 2002: Deposits of earthenware clay in southwest Cape Breton; *in* Minerals and Energy Branch, Report of Activities 2001; Nova Scotia Department of Natural Resources, Report ME 2002-1, p. ??

Digital Information Services

B. E. Fisher, J. C. Poole, J. D. MacNeil and J. S. Saunders

The Digital Information Services group is responsible for developing and maintaining the Minerals and Energy Branch (MEB) Geographic Information System and associated databases, the NovaScan bibliographic geoscience database, for supplying digital data and services to clients and staff, and for developing the MEB Internet web site. Permanent Digital Information Services staff consist of geologists / GIS specialists Brian Fisher and Jeff Poole, and web technician Susan Saunders. Adam Sherry and Bev Smith, both geology students, were hired to work with the group on casual basis over the past year. Kathy Mills was hired on a Geological Survey of Canada contract for three months to work on compiling geochemistry metadata. John MacNeil, a geologist / GIS specialist and Miranda Huskins, a geologist, were hired in November 2000 to work on the Targeted Geoscience Initiative (TGI) project in south-central Cape Breton Island.

Digital Geoscience Data Products

A collection of digital geology maps, databases and images of Nova Scotia (in DXF, ARC export, ArcView® shapefiles, TIFF, and JPEG formats in a UTM projection using the NAD27 datum, and in PDF format) has been developed and is now on sale through the library and available for free download from the MEB web site at http://www.gov.ns.ca/natr/meb/pub3.htm. The complete list of digital data products available can be seen in Appendix 3. This list can be obtained from the Halifax DNR Library or viewed on the MEB web site at http://www.gov.ns.ca/natr/meb/pubshome.htm. A licence agreement is issued with all digital data sets. This agreement allows unrestricted use of the data with the understanding the DNR remains the owner of the data and is not transferring copyright to the user. Since March 1999, when data were first made available for download from the MEB web site, there have been over 20,000 downloads.

Public Access GIS

A Public Access GIS has been developed for use by clients in the Halifax library. This is a user-friendly query and display system that uses a customized version of ArcView® to access a variety of geographically referenced digital geoscience data on Nova Scotia. It can display and query data sets, overlay various themes of geoscience, topographic and land-use information, and plot the resulting maps in colour. Version 3 of the Public Access GIS is currently being worked on and will contain many new themes and an improved menu system. This version should be available in 2002.

GIS Development

Digital Information Services staff have been working cooperatively with MEB staff on several projects, including creating the digital layers to be used as part of the Metro Aggregate Project and two maps which are being released as part of the project, namely: Open File Map ME 2001-1, Map of Bedrock Aggregate Potential in the Halifax - Dartmouth Metropolitan Area, Nova Scotia; and Open File Map ME 2001-2, Map of Land Use Constraints in the Halifax - Dartmouth Metropolitan Area, Nova Scotia.

The GIS version of the Registry of Mineral and Petroleum Titles database was updated several times. Two new versions (2 and 3), of the Mineral Rights Disposition Map for the Province of Nova Scotia (OFM ME 2000-6) were released.

Work is continuing on converting the NovaScan database into Arc/Info® format. When completed, the database will be made available in the Public Access GIS and on the Internet in 2002.

Work has continued on converting 48 bedrock geology maps from Fieldlog® / AutoCAD® format into ArcInfo® and incorporating these maps as part

of our GIS. These maps will be completed and released as digital products in 2002.

Internet Map Projects

Jeff Poole has created several prototype Internet Map Server (IMS) applications, currently running in-house, that will allow our clients to view, query, plot and download our digital maps and databases over the Internet. Over the next year Jeff will be committing much of his time to producing an Internet application, using ArcIMS® technology, that will provide the general public with Internet access to our Public Access GIS layers. It is planned that the initial deployment of this application will be in 2002.

Targeted Geoscience Initiative (TGI) Project in South-central Cape Breton Island

In the summer of 2000 the Geological Survey of Canada (Atlantic) and the Minerals and Energy Branch were awarded funding under the Geological Survey of Canada Targeted Geoscience Initiative (TGI) for a geological mapping project to aid mineral development in south-central Cape Breton Island. As part of this project we are responsible for producing a digital compilation of geological data for this area. John MacNeil and Miranda Huskins were hired in November 2000 to work exclusively on this project to build databases, digitize maps and develop the digital products that will be produced as a result of this project. We have identified approximately 90 layers that may potentially be included as part of the final products for this project. To date, approximately 20 maps have been digitized and many other layers have been developed for inclusion in the compilation. A web site for the project is currently under development.

Canadian Geoscience Knowledge Network

The Canadian Geoscience Knowledge Network (CGKN) is a collaborative effort between the 12 provincial and territorial geoscience agencies and the federal Geological Survey of Canada, which operates six offices across Canada. The plan is for the CGKN to be a single window of access, using the Internet, to the geoscience holdings of all the surveys. MEB has been involved in two CGKN projects over the past year.

In January 2001 Kathy Mills was hired for three months under contract to the GSC, as part of the Geochemistry On-line project, to begin compiling metadata on regional geochemistry surveys and databases so that the information can be entered into the CGKN geochemistry data model. The metadata for three surveys, consisting of five databases, was completed by the end of the contract at the end of March 2001.

In October MEB received funding from the CGKN Metadata Catalogue Project to develop a metadata server, which is part of a distributed network of metadata servers, and a database containing metadata describing our digital data products and our publications, which will be searchable over the Internet by CeoNET and the CGKN metadata search engine. The money we received was used to hire Jeff McKinnon to work on this project for six months from September 2001 - March 31, 2002. Jeff has been working in ArcCatalog® and creating metadata for many of our digital products.

NovaScan

NovaScan is the bibliographic geoscience database on Nova Scotia and its offshore regions. As of December 31, 2001, the database contained 14,977 MEB records, consisting of 6,573 mineral exploration assessment reports, 3,566 publications, 2,693 open files, 1,200 journal literature references, 756 theses, 172 contribution series, 12 digital publications, and 5 outside publications.

NovaScan was updated with 96 new records in 2001: 56 assessment reports, 31 publications, 2 open files, and 7 contribution series.

In 2001, 114 assessment reports were publicly released from confidential status. Each month, a list

of open assessment reports was generated from NovaScan®, distributed to the DNR Library, the Core Library in Stellarton, and to the three Regional Geologists in Coxheath, Bible Hill and Bridgewater, as well as posted on the MEB web site. Quarterly reports were produced and published in the *Nova Scotia Minerals Update* newsletter, and on the web site.

In order to provide better service to our staff and clients by allowing Internet access to and searching of the NovaScan® database, two independent projects were continued in 2001. The first project involved downloading the database into the MEB GIS and creating geographic boundaries for all NovaScan® records. When complete, the NovaScan® database will be searchable through MEB's Public Access GIS, and also searchable on the Internet. Completion of this project should take place in 2002.

The second project involved downloading and converting the NovaScan® records into standard library MARC® format, so that they could be loaded into the Provincial Library's Internet-accessible *NcompasS* catalogue database. This catalogue can be accessed at the following address: http://ncompass.library.ns.ca. After selecting your language of choice (English/French), select Nova Scotia Department of Natural Resources from the available catalogue listings, and you will then be able to search all the DNR Library records including the NovaScan® records. As of December 31, 2002, all non-confidential NovaScan® records were entered into the *NcompasS* database. Newly released assessment reports are added to the *NcompasS* catalogue on a monthly basis.

Minerals and Energy Branch Web Site Development

The following publications were posted on our web site in 2001:

Report ME 2001-2 Mining Matters for Nova Scotia.
Report ME 2000-1 Report of Activities 1999.
Open File Map ME 2000-6 Mineral Rights Disposition Map for the Province of Nova Scotia.
Bulletin ME 5 Salt and Potash Resources in Nova Scotia, by R. C. Boehner, 1986, 346 pages, 8 1/2" x 11" format, includes Nova Scotia Department of Mines and Energy Map 1983-3, scale 1:500 000.
Bulletin ME 3 Assessment of Peat Moss Occurrences in Guysborough, Antigonish, Pictou, Colchester and Cumberland Counties, Nova Scotia, by D. R. Sutherland and F. S. Shea, 1976, 301 pages.
Minerals Update Newsletter: Volume 18, Numbers 1, 2, 3 and 4.
Open File Report ME 2001-2 Geology of the South Mountain Batholith, Southwestern Nova Scotia, by M. A. MacDonald, 2001, 359 pages, 1 map (includes Map ME 1994-1).
Open File Report ME 2001-1 Fault-controlled Zinc Mineralization in the Antigonish Highlands, Antigonish and Pictou Counties, Nova Scotia, by G. A. O'Reilly, 2001, 9 pages, 6 coloured figures.
Pan-American Conference on Research on Fluid Inclusions (D. J. Kontak).

Mercury in Till, Kejimkujik National Park Area (NTS 21A/06), Nova Scotia

T. A. Goodwin, P. K. Smith and B. M. Culgin[1]

Introduction

Environment Canada (1998) identified loons in Kejimkujik National Park (Fig. 1) as having the highest levels of mercury (Hg) concentration in blood of any loon population tested in North America. A multi-disciplinary team of research scientists has been studying the potential source(s) and process(es) that may account for the anomalous Hg levels in loons from the park. As part of the overall research objective, this study examines naturally occurring (geogenic) Hg in the <63 micron size fraction of till in the Kejimkujik National Park area as a possible source of Hg in the food chain.

A study of Hg in soil gas was also undertaken during the 2000 field season till sampling program. Results for Hg in soil gas from the Kejimkujik Park area have previously been reported by Goodwin and Page (2001). All work to date has been carried out through funding from Health Canada under the Toxic Substance Research Initiative (TSRI).

Geology

Bedrock Geology

The study area consists of Cambro-Ordovician metawacke and minor interbedded metasiltstone of the Goldenville Formation overlain by finely laminated slate and metasiltstone of the Halifax Formation (Horne and Corey, 1994; Corey and Horne, 1994). These rocks were intruded by Devono-Carboniferous monzogranite (Scrag Lake Pluton and Kejimkujik Pluton) and leucomonzogranite (Davis Lake Pluton) of the South Mountain Batholith (Horne and Corey, 1994; Corey and Horne, 1994).

Structurally, the metasediments are characterized by a series of northeast-southwest anticlines and synclines (Horne and Corey, 1994; Keppie, 2000). Two significant northeast-southwest zones of intense brittle-ductle deformation are inferred to transect the study area. The East Kemptville Shear Zone (EKSZ: Kontak *et al.*, 1986) cuts across the northern boundary of the park and the Tobeatic Shear Zone (TSZ: Corey, 1995) cuts across the southern boundary of the park (Fig. 2).

Mineralized zones, including Au-As-Sn-W-Mo-Cu-Ag-Pb-Zn-Ba, and variably altered (chloritized, silicified, kaolinized, hematized), brecciated boulders exhibit a strong spatial relationship with known and inferred structures (Horne and Corey, 1994; Corey, 1995). Corey (1995) suggests the types and styles of mineralization observed in boulders and diamond-drill core from the Tobeatic Shear Zone are similar

Figure 1. Map of Nova Scotia showing the location of Kejimkujik National Park.

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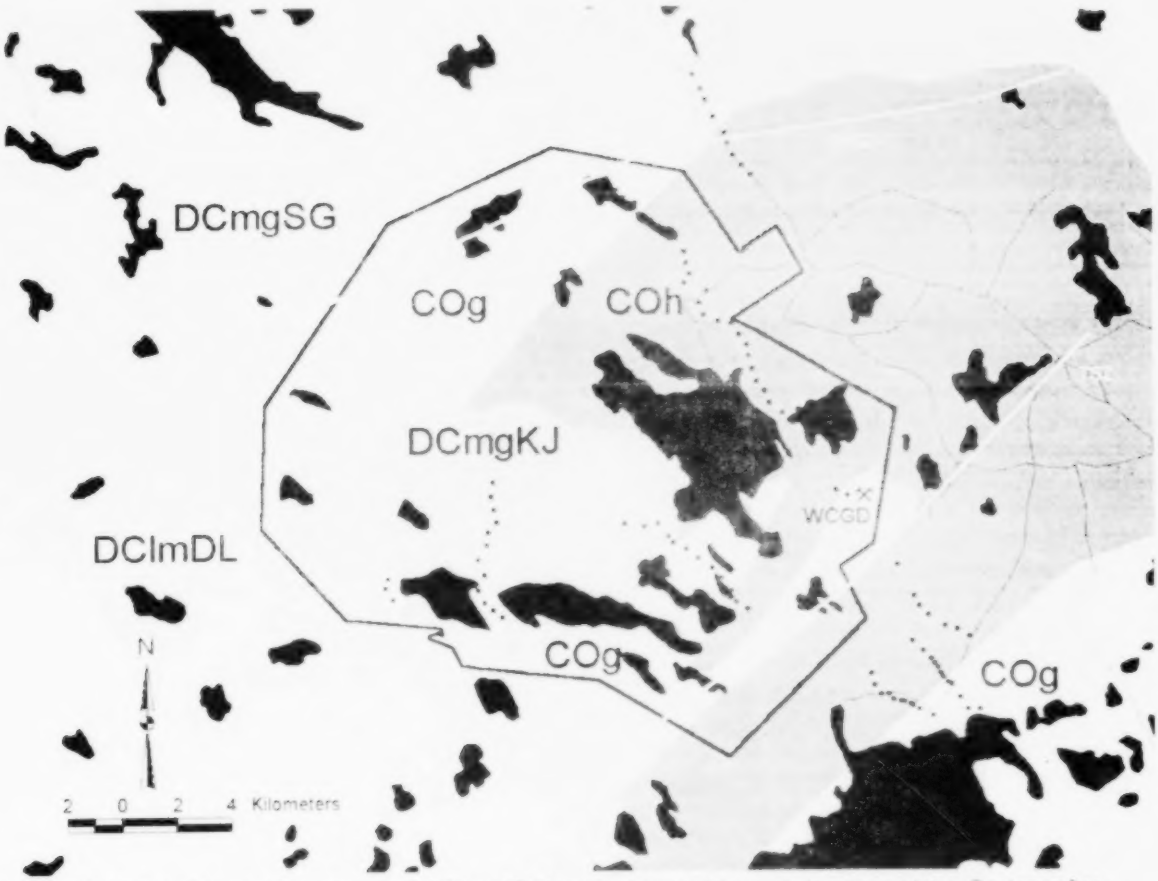


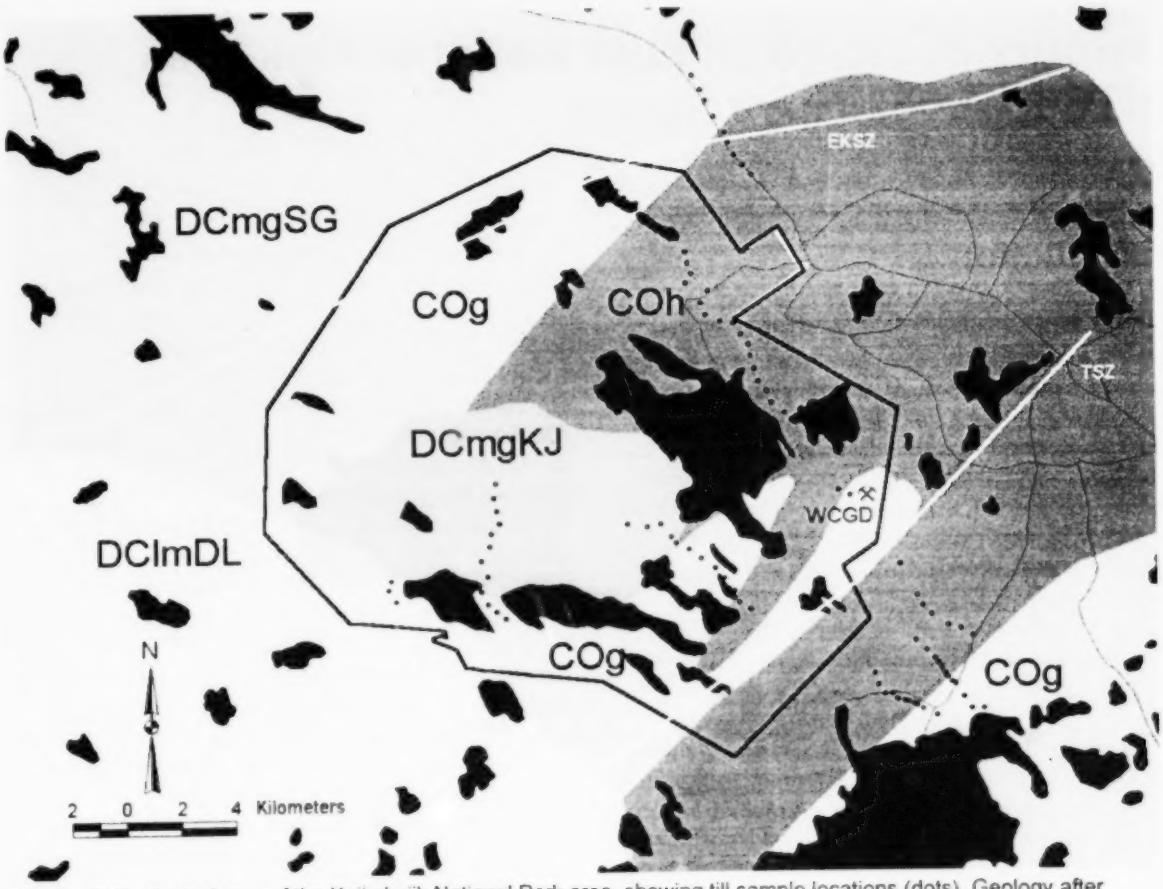
Figure 2. Geological map of the Kejimkujik National Park area, showing till sample locations (dots). Geology after Horne and Corey (1994). DCmgSG = Scrag Lake monzogranite, DCmgKJ = Kejimkujik monzogranite, DClmDL = Davis Lake leucomonzogranite, Coh = Halifax Formation, COg = Goldenville Formation, TSZ = approximate trace of the Tobeatic Shear Zone, EKSZ = East Kemptville Shear Zone and WCGD = West Caledonia Gold District. Note: the six samples collected along the western shore of Little Tobeatic Lake are not shown; Little Tobeatic Lake is approximately 14 km southwest of the southern park boundary.

to epithermal deposits elsewhere in the world. Epithermal deposits are characterized by the presence of Hg in the form of cinnibar (HgS) among other ore minerals, including minerals containing Au-Cu-Ag-Pb-Zn-Sb-Se-Bi-U (Evans, 1993).

Surficial Geology

The surficial geology of the study area is dominated by: (1) the Beaver River Till, a relatively thin, stoney till that is locally derived; and (2) the Shelburne River Till, a more distally derived till that is geomorphologically characterized by hummocks, ridges and a rolling ground moraine (Finck *et al.*, 1994b). Locally, however, the surficial geology is characterized by a silty drumlin facies, particularly along the eastern edge of the park boundary, and by ice contact glaciofluvial deposits, organic deposits, and bedrock-dominated terrain (Stea *et al.*, 1992; Finck *et al.*, 1994b).

Ice flow indicators suggest glacial ice originally flowed to the southwest, then shifted southerly, and finally flowed westward (Stea *et al.*, 1992). Field mapping during the 2000 and the 2001 field seasons confirmed the presence of these three flow directions.



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Previous Geochemical Sampling Programs

Nova Scotia has been extensively covered by regional geochemical surveys from various sample media including vegetation, till, stream sediments, stream waters, lake sediment, and lake waters. Three regional geochemical surveys have been completed over the Kejimkujik National Park area. Two of these were till surveys, one designed to sample till associated with the South Mountain Batholith from 1984 to 1989 (Boner *et al.*, 1990) while the other survey was designed to sample till over mainland Nova Scotia between 1977 and 1988 (Stea, 1982, 1983; Stea and Grant, 1982). Both surveys included samples within the Kejimkujik study area; however, no analysis for Hg was made in either till survey.

A 1977-1978 lake sediment survey completed over southern mainland Nova Scotia sampled numerous lakes within the current Kejimkujik study area (Richardson and Bingley, 1980). The lake sediment was analyzed for gold and other elements, including Hg. The study area is characterized by Hg levels ranging from 10-860 ppb in lake sediment, however; locally monzogranite has slightly elevated Hg relative to Meguma Group metasediments.

Methodology

Introduction

During the 2000 and 2001 field seasons, a total of 97 till samples were collected at 500 m intervals along eight northwest-southeast roadside traverses located in the park, and to the northeast and southeast of the park (Fig. 2). However, some samples were also collected along footpaths (within the former West Caledonia Gold District) and from a pace and compass line along the west shore of Little Tobeatic Lake, 14 km southwest of the park.

The traverse lines were oriented to (1) sample the dominant till units, (2) cross all bedrock units (Goldenville Formation, Halifax Formation and granite), including the Goldenville-Halifax Transition Zone (GHTZ), (3) cross the Tobeatic Shear Zone and the East Kemptville Shear Zone, (4) assess the possible correlation of Hg with known Au mineralization associated with the former West Caledonia Gold District, and (5) to take advantage of pre-existing roads.

Sampling Methodology

Till samples were collected by shovel and/or hand auger from an average sampling depth of about 1 m. Approximately 500 g of till were collected at each site and placed into a Kraft sample bag for geochemical analysis. The Kraft sample bags were immediately placed in coolers, which also served as shipping containers to the laboratory. During the 2000 field season, an additional 3 kg sample was collected from each sample site and placed into 6 ml plastic sample bags for clast identification and count.

At each sample site, detailed notes were recorded, including observations on till type, colour and texture. Sample sites were geo-referenced to the Universal Transverse Mercator (UTM) grid (NAD 27) with a GARMIN GPS 12. Each sample site was photographed as a permanent record for future reference.

Analytical Methodology

The 500 g till samples were forwarded in the Kraft bags to DalTech Minerals Engineering Centre in Halifax, Nova Scotia, for drying and sieving. All samples were dried to a maximum drying temperature of 35°C.

Once dried, approximately 10 g of the <63 microns fraction were sieved and placed into a set of pre-labeled vials for Hg analysis. An additional 50 g of the <63 micron fraction were sieved and subsequently placed into two sets of pre-labeled vials for gold and multi-element analysis.

Vials containing the 10 g of the <63 micron material were sent to ACME Analytical Laboratories of Vancouver, British Columbia. A subsample of 1 to 2 g was analyzed for Hg by Cetac Cold Vapour Atomic Absorption (Cetac CV-AA) with a lower detection limit (LDL) of 1 ppb.

One set of the larger 50 g vials was sent to Bondar Clegg in Val d'Or, Quebec, for geochemical analysis. A 30 g subsample was analyzed for gold by Fire Assay/Atomic Emission Spectroscopy (FA/AES) and a 1 g sample was analyzed for multi-element geochemistry by Inductively Coupled Plasma/Atomic Emission Spectroscopy (ICP/AES) following an aqua regia digestion.

The remaining set of 50 g vials was retained for archival purposes.

Quality Assurance/Quality Control

Strict Quality Assurance/Quality Control protocols and procedures were implemented at all stages of the till sampling program, including program planning, training, sample collection, sample preparation and sample analysis, to ensure the integrity of the data set. Quality Control procedures included: (1) the collection of field duplicates, (2) the insertion of preparation splits, and (3) the insertion of certified and in-house reference standards.

To assess precision, ACME also re-ran the first 34 samples submitted in 2000 for Hg by Inductively Coupled Plasma/Mass Spectrometry (ICP/MS) as a check on the Hg levels reported by the Cetac CV-AA method. Similarly, random samples for the Au and multi-element geochemistry results reported by Bondar Clegg were sent to a second laboratory for comparison.

Results

While the complete till data set is still currently being assessed and integrated with other geochemical, geological and geophysical data sets, some important preliminary Hg results (observations) are presented here for the first time.

Based on the Quality Control data, the analytical data are deemed to be of excellent quality. However, a minor degree of spatial variance was noted in several of the field duplicate pairs. The nature and extent of the spatial variance is not clearly understood at this time. A number of explanations, including sample inhomogeneity and/or the distribution of Hg within the till matrix, may be responsible for the variance.

The geochemical response for any element observed in till typically characterizes the parental bedrock material (geological variability) from which it was derived, its mode of transportation and deposition, and post-deposition weathering effects. Therefore, results for Hg in the <63 micron fraction of till have been subdivided on the basis of the various till units of Finck *et al.* (1994a, 1994b) observed during the till sampling program. Basic statistical results for Hg are presented in Table 1.

The slate facies of the Beaver River Till (SLB) has the lowest mean of Hg value (41.4 ppb) for the <63 micron fraction, followed by the greywacke facies (50.3 ppb) of the Beaver River Till (GWB) and the granite facies (67.3 ppb) of the Beaver River Till (GTB). Although samples were collected from areas designated as Shelburne River Till by Finck *et al.* (1994a, 1994b), no Shelburne River Till was observed in the 2000-2001 sampling program, indicating some minor modifications to the existing surficial maps is required.

The highest mean Hg value (99.3 ppb) in till came from six samples collected approximately 14 km southwest of the southern boundary of Kejimkujik National Park. This small population of samples was collected from the greywacke facies of the Beaver River Till (GWB), not from Shelburne River Till as indicated by Finck *et al.* (1994a). At this location, the Tobeatic Shear Zone is exposed on the western shore of Little Tobeatic Lake. Evidence of the shear zone includes a several-metre-wide west-southwest-trending quartz vein/stockwork system traceable for several hundred metres of strike length, associated variable carbonate-altered greywacke wallrock, and locally intense sulphide mineralization. Physical evidence of the shear zone, including quartz clasts and boulders and sheared, foliated and silicified meta-sedimentary boulders, was noted in several till pits. This zone was further delineated by diamond-drilling (Corey, 1995).

On a global scale, Jonasson and Boyle (1972) speculated that deep faulting and shearing may be a

Table 1. Mercury (ppb) in till (<63 microns).

	SLB* (slate till)	GWB* (greywacke till)	GTB* (granite till)	GWB* (samples of greywacke till from the Tobeatic Shear Zone)
Mean	41.4	50.3	67.3	99.3
Median	37.9	44.6	70.0	92.3
Std. Dev.	28.89	33.28	46.90	56.34
Min.	6.4	6.6	3.4	32.2
Max.	151.5	96.6	158.5	193
No. of samples	49	11	31	6

*Till unit descriptions from Finck *et al.* (1994a, 1994b).

characteristic of all Hg occurrences. In British Columbia, Plouffe (1997) observed an increase in Hg content in the <2 micron size fraction of till down-ice from major structures characterized by several Hg occurrences. Goodwin and Page (2001) suggested that there is a spatial correlation between the inferred trace of the Tobeatic Shear Zone and elevated Hg in soil gas in the Kejimkujik National Park area.

The Hg concentrations from this study are, in general, within the range of the normal Hg content in till (20-100 ppb, mean 50 ppb) reported by Jonasson and Boyle (1972). The exceptions are the six samples from the Tobeatic Shear Zone that have a mean value (99.3 ppb) two times the mean of normal till (50 ppb) reported by Jonasson and Boyle (1972). It is important to note that Jonasson and Boyle (1972) do not specify the size fraction of till analyzed or the analytical method used to determine the Hg content of till. Locally, the presence of elevated Hg along the Tobeatic Shear Zone indicates a spatial relationship between the shear zone and Hg. The shear zone, therefore, is a geogenic source of Hg in the Kejimkujik National Park area. However, the presence of Hg in every till sample collected for this study indicates that an additional source, or sources, of Hg exists.

On the basis of only two till samples, there does not appear to be a relationship between Hg and the former West Caledonia Gold District. The mean Hg level from the two till samples collected was 37.8 ppb. However, in order to quantify the relationship, significantly more till sampling from within the district is required.

The contribution from anthropogenic Hg affecting till samples collected during the 2000-2001 field season is believed to be nil. Henderson and McMartin (1995) reported that anthropogenic Hg fallout from within 3 km of a smelter in Flin Flon, Manitoba, was limited to a maximum depth of 45 cm. The minimum sample depth from the 2000-2001 sampling program was 50 cm. Only 4 of the 97 samples collected for the 2000-2001 sampling program were from a depth of 50 cm. There appears to be minimal potential for excessive anthropogenoic Hg in the Kejimkujik National Park area. No smelters exist in Nova Scotia and the closest heavy industry is located approximately 60 km to the east.

Conclusions

A total of 97 till samples were collected mostly from roadside traverses and analyzed for mercury (Hg) as part of a larger study in an attempt to identify a source of high Hg levels in the blood of loons from Kejimkujik National Park.

Naturally occurring Hg in the <63 micron size fraction of till exists in the Kejimkujik National

Park area. Mean Hg levels are variable and dependent on the till unit sampled. For example, the lowest mean value of 41.4 ppb Hg characterizes the slate facies of the Beaver River Till, compared to 50.3 ppb for the greywacke facies and 67.3 ppb for the granite facies. These mean levels are similar to the normal Hg content of till reported by Jonasson and Boyle (1972) of 50 ppb. However, local geological influences such as shearing, brecciation, alteration and mineralization may influence the Hg content of till. Till samples collected from the greywacke facies of the Beaver River Till over the Tobeatic Shear Zone returned the highest mean Hg level for this study, 99.3 ppb. The elevated response over the Tobeatic Shear Zone is two times the normal Hg content of till (Jonasson and Boyle, 1972).

Further Studies

The issue of spatial variance of Hg in till needs to be resolved. Additional sampling involving the collection of field duplicates is required. Additional sampling from within the West Caledonia Gold District is also required to assess if a correlation exists between the gold mineralization and Hg.

The source of Hg in till will need to be identified. This would involve the determination of the form(s) of mercury and its relationship to till, whether it is: (1) being adsorbed onto clay, (2) present within the crystal lattice of one or more minerals, or (3) in the form of clastic grains. The relative abundance of Hg in a stratigraphic section also needs to be determined, as does the glacial comminution terminal grade. This will involve detailed depth profile sampling of the till unit(s), size fraction analysis, sequential leach analysis, clast counts, mineralogical identification and mineral probing.

In order to put the concentration of Hg in till from the Kejimkujik National Park area into proper context, the Hg content of till throughout the province will have to be assessed. Once this work is complete, results can be compared to comparable studies throughout Canada.

Additional new data sets, including recent bedrock and surficial geologic mapping, detailed ground magnetics, and lithogeochemistry have yet to be integrated with the till geochemical data set. Once all the data have been fully integrated, correlation of Hg with the new data sets and other elements from the till can be undertaken.

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Geology of the Dufferin Gold Deposit (NTS 11D/16), Halifax County

R. J. Horne and M. Jodrey[1]

Introduction

This report describes the geology of the Enviro-Gold Dufferin gold deposit, currently being operated by EnviroGold Technologies Inc. The deposit is located approximately 8 km north of Port Dufferin (Fig. 1) and occurs in the hinge of the Crown Reserve Anticline (CRA) (Fig. 2a). The CRA represents the faulted extension of the Dufferin Mines Anticline, where previous mining and exploration occurred, particularly at Dufferin Mines, where reported gold production was 41,801 oz. (Bates, 1987). Previous mining on the CRA included minor development on the south limb of the fold at the Crown Reserve and Maple Leaf mines (Fig. 2a). Extensive exploration, including diamond-drilling by Seabright Resources in the 1980s (Mitchell, 1988), lead to the discovery

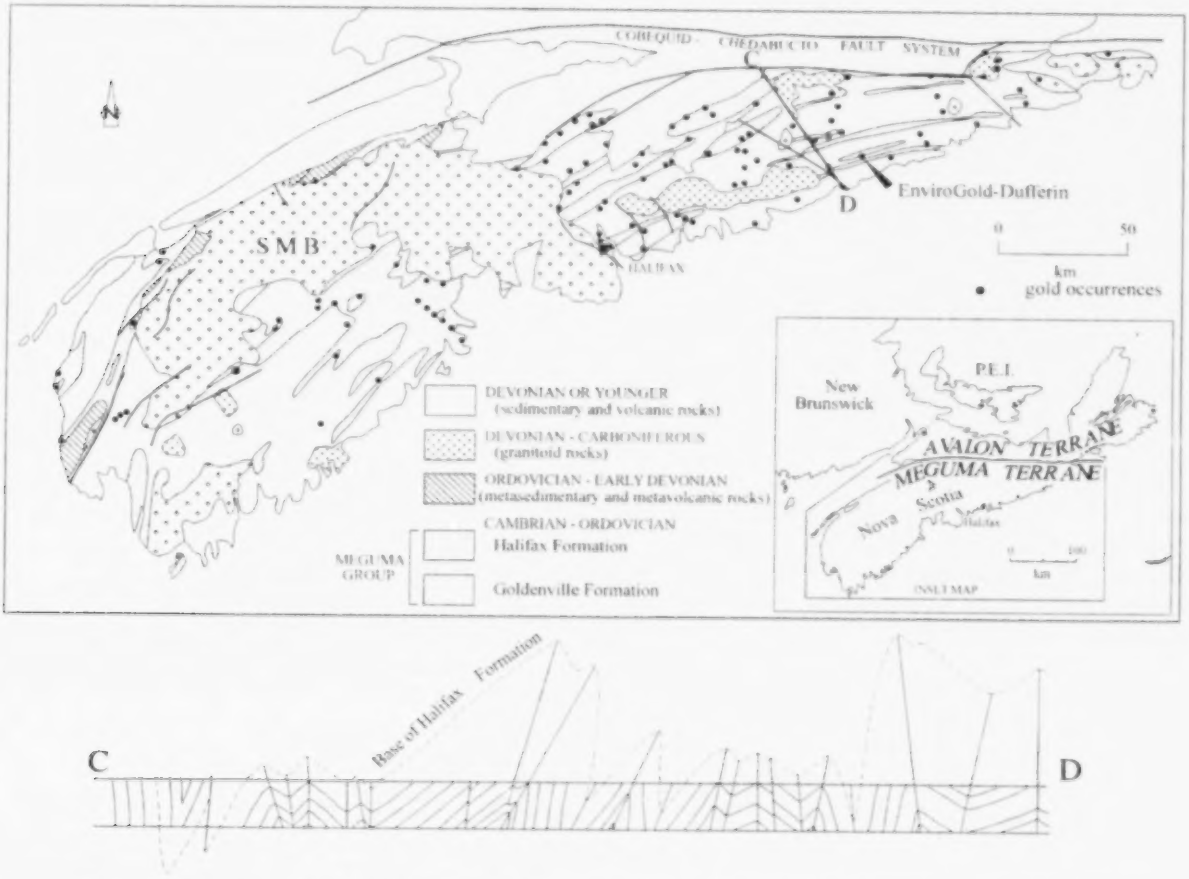

Figure 1. Simplified geological map of the Meguma Terrane showing distribution of gold deposits and the location of the EnviroGold Dufferin deposit.

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of auriferous saddle-reef veins in the hinge area of the CRA. During the 1990s Dufferin Resources completed further diamond-drilling which established approximately 700 m strike extension for the upper two saddle-reef veins, and potentially up to 13 saddle-reef zones indicated by a single diamond-drill hole (Jacques Whitford and Associates, 1993; Figs. 2b, c). Current development of the deposit by EnviroGold commenced in late 2000 and as of the end of 2001, mine development has extended to the third saddle-reef vein. The majority of mining has occurred on the second saddle-reef vein (Fig. 2c).

General Geology

Previous work has indicated that the Dufferin Mines and Crown Reserve anticlines represent the south fold of a pair of closely spaced anticlines (Fig. 2a), including the Salmon River Anticline, which define the hinge area of a regional-scale anticlinorium (Dawson, 1899; Malcom, 1929; Mitchell, 1988). The character of the anticlinorium outside the gold mines has not been defined, and is represented by a single anticline trace on regional maps (Faribault, 1897; Henderson, 1986). Within the Dufferin Mines deposit (Fig. 2a) the Salmon River Anticline is described as more open than the Dufferin Mines Anticline, and the saddle vein system is apparently restricted to the southern fold (Dawson, 1899).

The Crown Reserve Anticline defines a tight (interlimb angle of ~47°; Fig. 2b) chevron-style fold which is steeply inclined to the south (Figs. 2b). The hinge zone of the fold typically defines a rounded arc-shaped structure approximately 5-10 m across and the limbs are uniform and straight. Variations noted in the hinge zone include local flat segments and minor M-folds, where the flat segment has been folded into an open syncline. A well-developed axial planar cleavage occurs, consisting of a spaced (pressure solution) cleavage in metasandstone and a fine continuous cleavage in metasiltstone and slate. There is strong cleavage refraction, from a convergent pattern in metasandstone, with bedding-cleavage angles of ~50°, to a divergent pattern in metasiltstone and slate, where cleavage is commonly subparallel to bedding.

Stratigraphy within the deposit consists predominantly of medium- to thickly-bedded metasandstone with lesser metasiltstone and slate (e.g. Fig. 3). A typical sedimentary sequence defines a fining-upward cycle of thick, massive metasandstone, gradationally overlain by laminated metasiltstone, in turn overlain by black slate. An average cycle includes approximately 1 m of metasandstone, 5-10 cm of metasiltstone, and 1-2 cm of slate. Some cycles are almost exclusively meatsandstone, with < 1 cm of slate, whereas other cycles include over 1 m of metasiltstone and slate.

The northwest-trending Harrigan Cove Fault offsets the regional fold and vein system, with approximately 1.5 km of sinistral strike-slip separation (Fig. 2a). In addition, a significant amount of dip-slip displacement is suggested by the variance in separation of the trace of the Salmon River Anticline and the Dufferin Mines Anticline west of the fault and the Salmon River and Crown Reserve anticlines east of the fault (Fig. 2a). Three significant faults offset the Crown Reserve Anticline, and vein array, within the developed portion of the deposit. These faults are herein referred to, from west to east, as faults 1, 2 and 3 (Fig. 2c). Faults 1 and 3 trend northwest, parallel to the Harrigan Cove Fault, whereas fault 2 runs north-south. All three faults display oblique movement, with sinistral, east-side-down displacement. The dip-slip displacement is less than the strike-slip displacement (compare plan and longitudinal sections, Fig. 2c.).

Structure and Vein Array

Introduction

As will be described in detail below, the auriferous vein array at the EnviroGold Dufferin gold deposit occupies mainly structures related to flexural folding: bedding-parallel shear, and hinge zone dilation. These veins can be grouped into (1) saddle-reef veins, generally defining thickened stratabound veins in the fold hinge, and (2) leg-reef veins, which represent the down-limb extension of saddle-reef veins (Fig. 4). In addition, there are numerous discordant veins, most of which are interpreted to be related to saddle- and leg-reefs. The vein system is generally similar to those

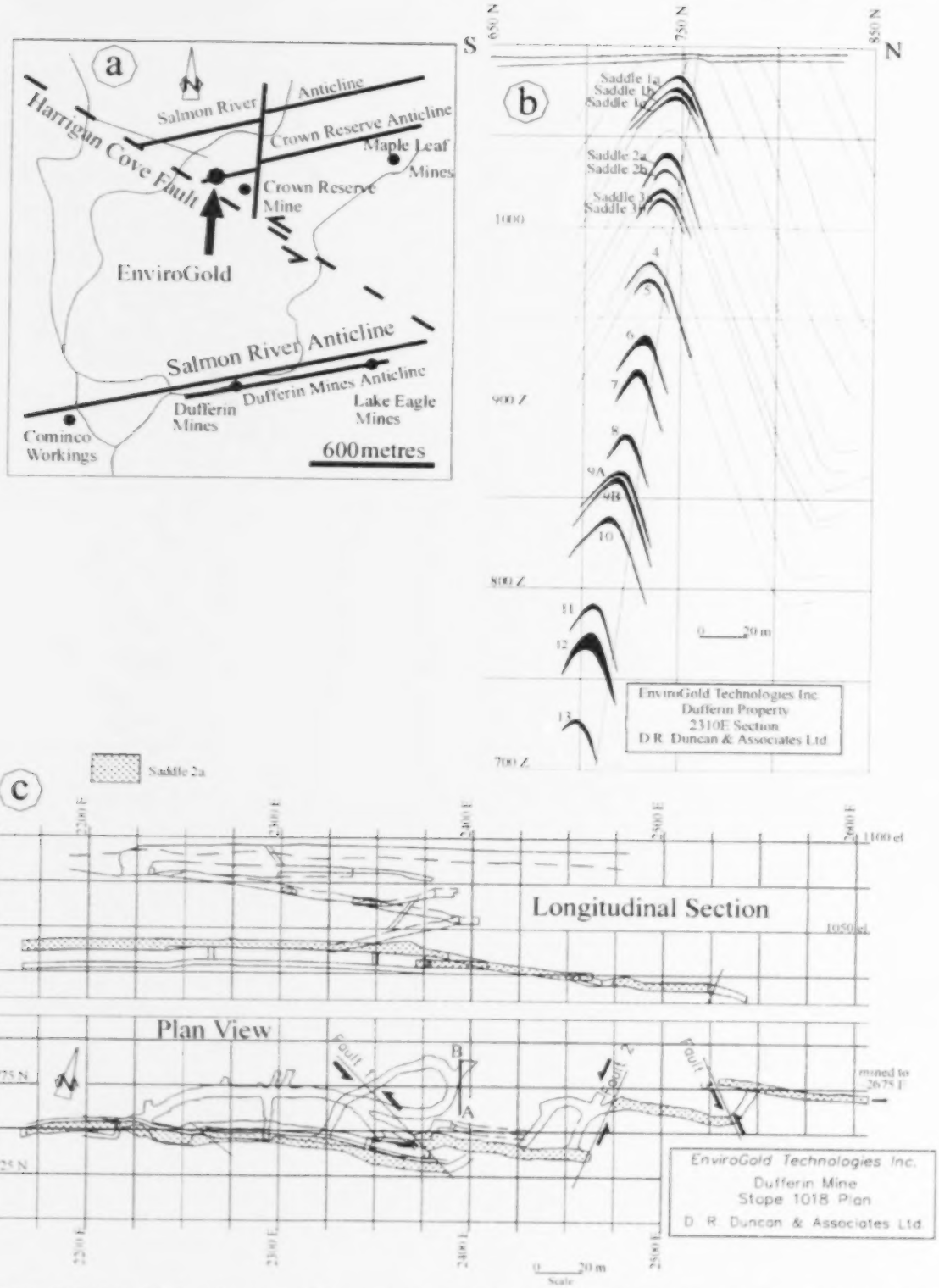

Figure 2. (a) Simplified geology map of the area of the Dufferin Mines and Crown Reserve anticlines, showing the location of previous mines and the EnviroGold Dufferin deposit. (b) Cross-section of the Crown Reserve anticline showing the occurrence of thirteen saddle-reef zones defined by drilling. (c) Plan view and longitudinal section of workings at the EnviroGold Dufferin deposit. The stoped area of saddle-reef 2a is indicated by the cross pattern.

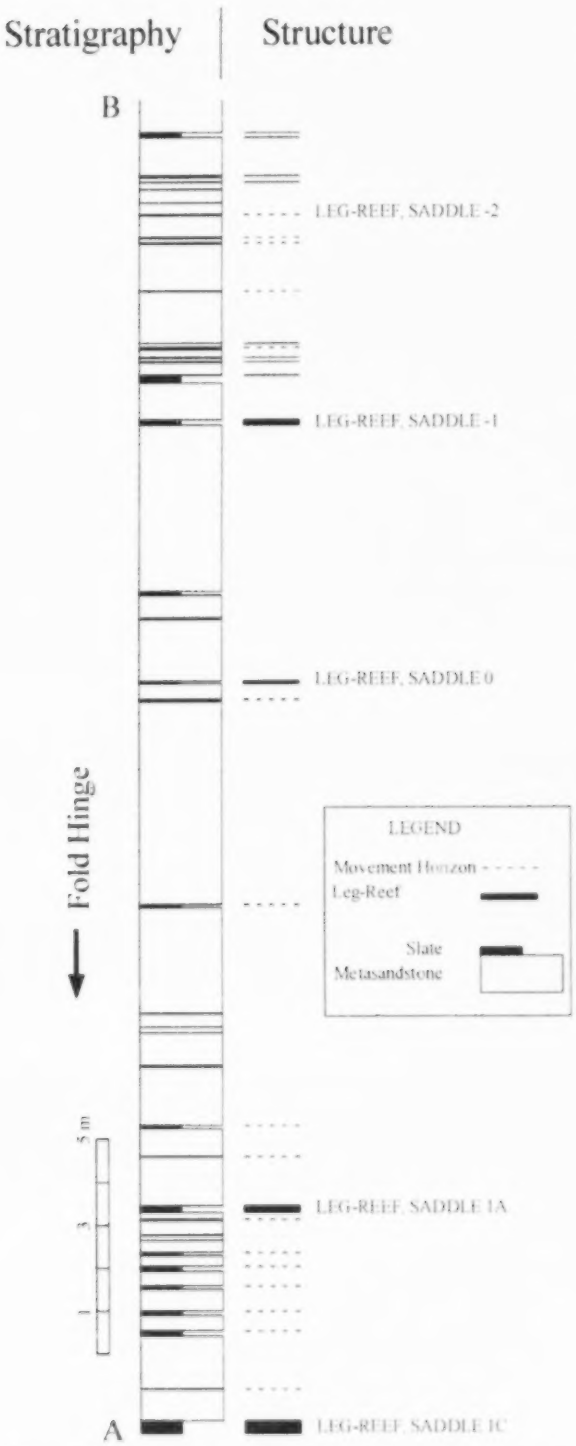

Figure 3. Stratigraphic-structural log of a section (A-B) of the north limb of the Crown Reserve Anticline exposed in the development ramp (see Figs. 2c and 5a for location). Flexural shear structures occur within most slate intervals, with movement horizons occurring at the top of slate beds.

documented in Central Victoria, Australia (e.g. Chace, 1949; Saniford and Kaeys, 1986; Ramsay *et al.*, 1998).

Flexural Shear Structures

Flexural folding is the dominant fold mechanism in the development of chevron-style folds in layered sequences, and results in bedding-parallel shear perpendicular to the fold hinge, where the structurally higher beds move toward the hinge (Fig. 4) (Ramsay, 1974; Tanner, 1989). Flexural shear strain is localized within the incompetent slate layers, where various minor structures are developed, whereas strain within competent layers is minimal (Ramsay, 1974). Abundant evidence of bedding-parallel shear related to flexural folding occurs within the deposit, recorded by minor structures within slate intervals, such as laminated bedding-parallel veins, en echelon shear veins, and movement horizons.

Movement Horizons

Movement horizons are bedding-parallel slip planes reflecting flexural slip. Movement horizons typically consist of thin zones of fault gouge (clay) developed within slate horizons, generally at the contact with overlying metasandstone beds (e.g. Figs. 3, 5b, 6b). The gouge is locally laminated and ranges from <1 mm to ~2 cm thick. The thicker gouge zones locally host angular clasts, including quartz vein material. Striations are developed in the soft gouge, trending roughly perpendicular to the fold hinge. Movement horizons typically occur at all slate-metasandstone boundaries and commonly occur mixed with other flexural-folding structures, such as laminated veins. Movement horizons locally occur at the same stratigraphic horizon on both limbs of the fold, and locally can be traced across the hinge zone (e.g. a movement horizon occurs at the hanging wall margin of saddle 1a across the hinge zone; Fig. 5).

Laminated Veins

Bedding-parallel laminated quartz veins occur within slate beds at several horizons, and represent the leg-reef extensions of some saddle-reef veins (e.g. Fig. 5a, d). The origin of

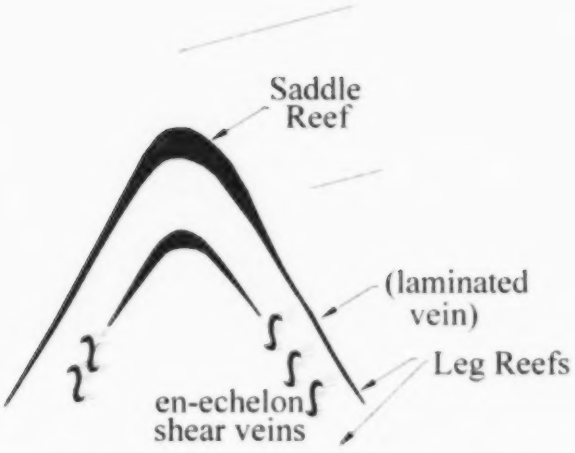

Figure 4. Sketch of a simplified fold showing location of saddle- and leg-reefs, the latter including laminated veins and zones of en echelon veins.

laminated veins within Meguma gold deposits, and elsewhere, has been the subject of much discussion (e.g. Chace, 1949; Henderson *et al.*, 1986, 1990; Tanner, 1989; Jessell *et al.*, 1995; Fowler, 1996). Our preliminary interpretation of laminated veins in the EnviroGold Dufferin gold deposit is that they represent incremental vein growth along bedding-parallel flexural-slip movement horizons. We base this on the following observations: (1) laminated veins represent leg reefs and, therefore, occur along horizons where high shear strains were required; (2) movement horizons occur within slate immediately adjacent to the veins; (3) striations occur on the surfaces between laminations within the vein. These striations are generally perpendicular to the fold hinge, although they vary between laminations, consistent with variations in slip vector between periods of vein growth. Movement horizons and striations could post-date vein formation; however, later slip would be expected to result in parallel striations on all laminations. A replacement origin for laminated veins has been proposed for the central Victoria deposits by Chace (1949), who interpreted the laminations to represent the vestiges of sheared slate, including slickensides, along bedding-parallel faults. We agree that replacement may contribute to vein formation, noting the important concept is that vein emplacement occurred along active bedding-parallel movement horizons.

En Echelon Veins

En echelon shear vein arrays are common in slate or metasiltstone beds throughout the deposit, in many instances representing the down-limb extension of saddle-reef veins (i.e. leg-reefs; Fig. 5b and 6b, d, g). The formation of en echelon veins on the limbs of flexural folds is common (Fig. 7a) and such veins have been described in the Meguma Group (Henderson *et al.*, 1986). Veins initiated as extensional "gash" veins at low limb dips are rotated during progressive shear, initially shortened forming sigmoidal shapes, and later extended resulting in boudinage of the veins (Figs. 7a, b). The ends of en echelon veins are "pegged" within metasandstone beds on both sides of host slate intervals. These pegs preserve the original geometric relationship with bedding, allowing for determination of the amount of shear strain recorded within the slate interval since vein formation (Fig. 7c). En echelon veins in the Dufferin deposit all record a high degree of shear (shear strains of 2-3 γ are common), and several display shear-related boudinage (e.g. Figs. 6d, e, g). Locally, some veins show multiple generations of vein development. A reverse sense of shear is indicated for all en echelon shear veins, changing systematically across the fold hinge, and the vein-bedding intersection is parallel to the fold hinge (Fig. 4), consistent with flexural shear perpendicular to the fold hinge. These observations clearly demonstrate a syn-folding origin for these veins.

Saddle-reef Vein System

As outlined above, the vein system is dominated by saddle-reef veins and associated leg-reef veins. Thirteen saddle-reef zones, some consisting of two or three closely spaced saddle-reef veins, have been encountered in diamond-drilling (Fig. 2b), and potential for more exists at depth. Three saddle-reef structures have been developed to date, each of which is distinct in its geometry and makeup.

Saddle-reef 1

Saddle-reef 1 includes three individual saddle-reef veins with associated leg-reefs, referred to, from

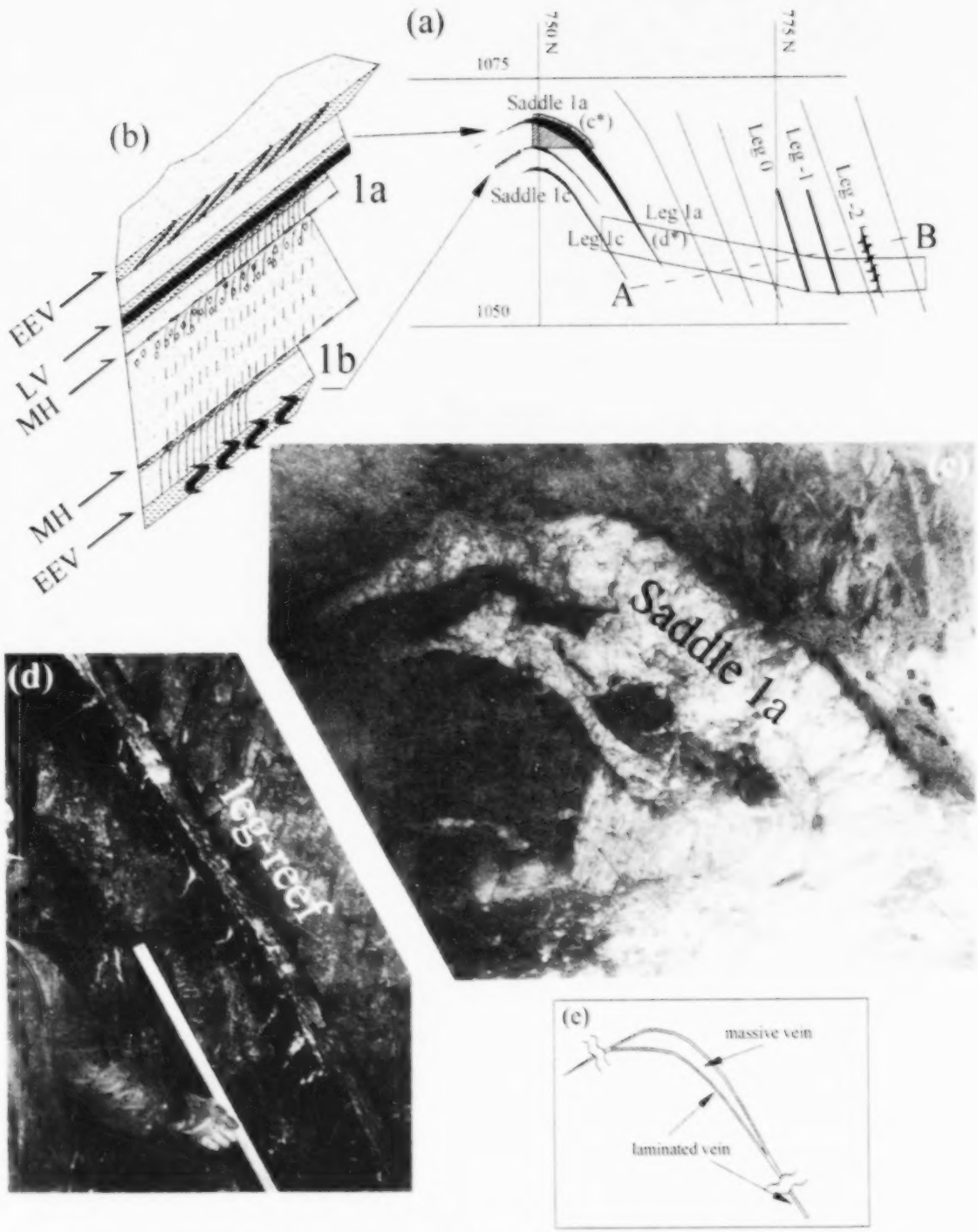

Figure 5. (a) Section at 2400 E showing fold geometry and distribution of saddle-reefs 1a-c and leg-reefs of stratigraphically higher saddle-reefs (Legs 0, -1, -2). Letters with * (e.g. c*) indicate the location of corresponding photograph. (b) Enlargement of a stratigraphic interval of the south limb, including saddle-reef 1a and 1b. Flexural shear structures within slate intervals include en echelon veins (EEV), movement horizons (MH), and laminated veins (LV). (c) Photograph of saddle-reef 1a showing the highly asymmetric geometry; see (b) for location. (d) Photograph of the leg-reef of saddle-reef 1a on the north limb. The leg consists of mainly laminated veins with en echelon veins formed in foot wall slate. Movement horizons are common within the slate with some minor displacement of en echelon veins is recorded; see (b) for location. (e) Schematic diagram of saddle-reef 1a showing the general distribution of massive and laminated veins within the saddle- and leg-reefs.

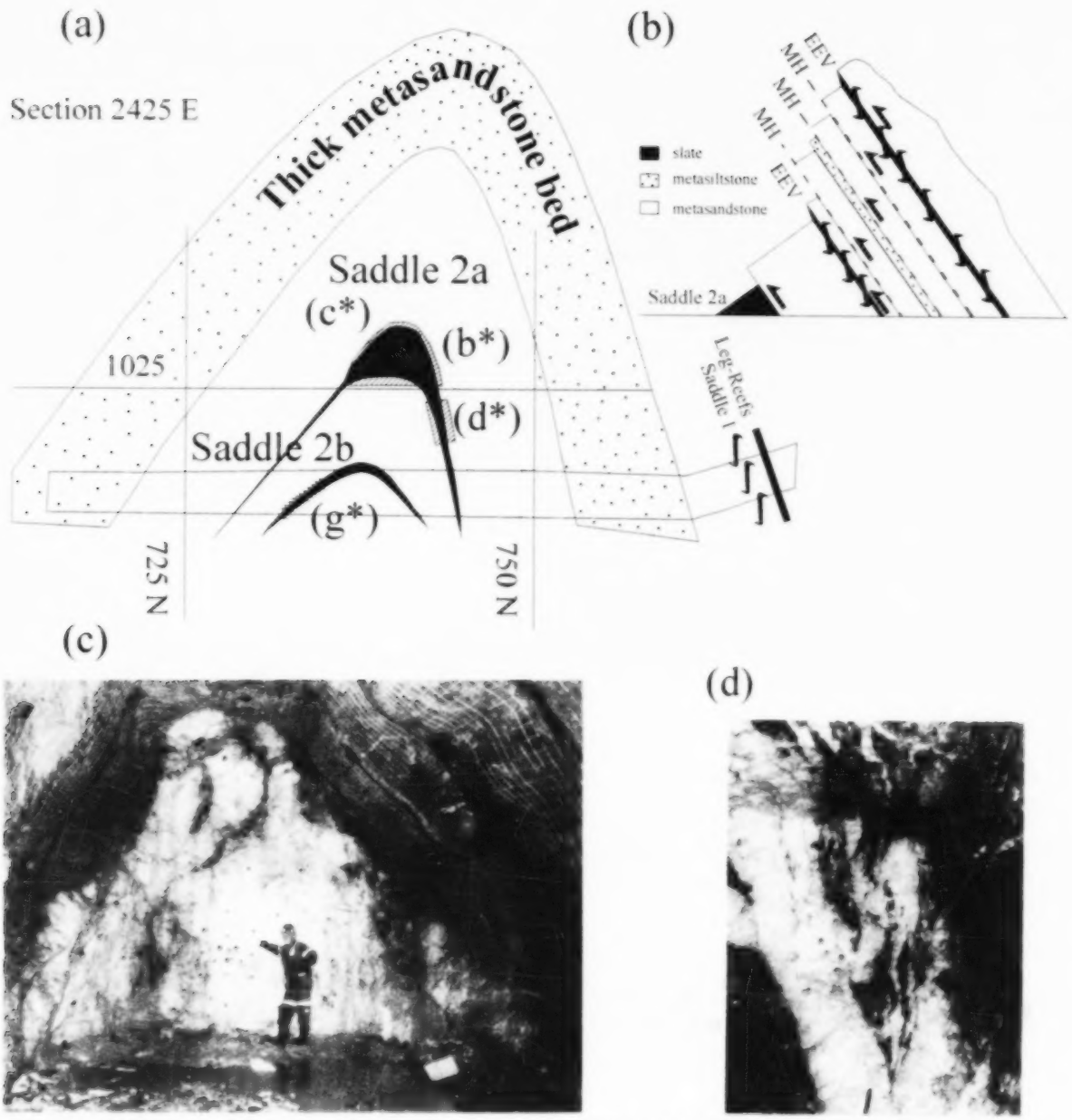

Figure 6. (a) General cross-section of saddle-reef 2 at 2425 E. Letters with * (e.g. b*) show the locations of Figures 6b-g. (b) Section of the hanging wall of saddle-reef 2a showing the distribution of en echelon veins (EEV) and movement horizons (MH) within slate and metasiltstone intervals. (c) Photograph of saddle-reef 2a at approximately 2250 E. (d) Photograph of the north leg-reef of saddle-reef 2a at approximately 2325 E. The vein consists of a massive, coarsely laminated bedding-parallel vein (BPV) and a zone of strongly sheared (boudinaged) en echelon veins (EEV) in the hanging wall.

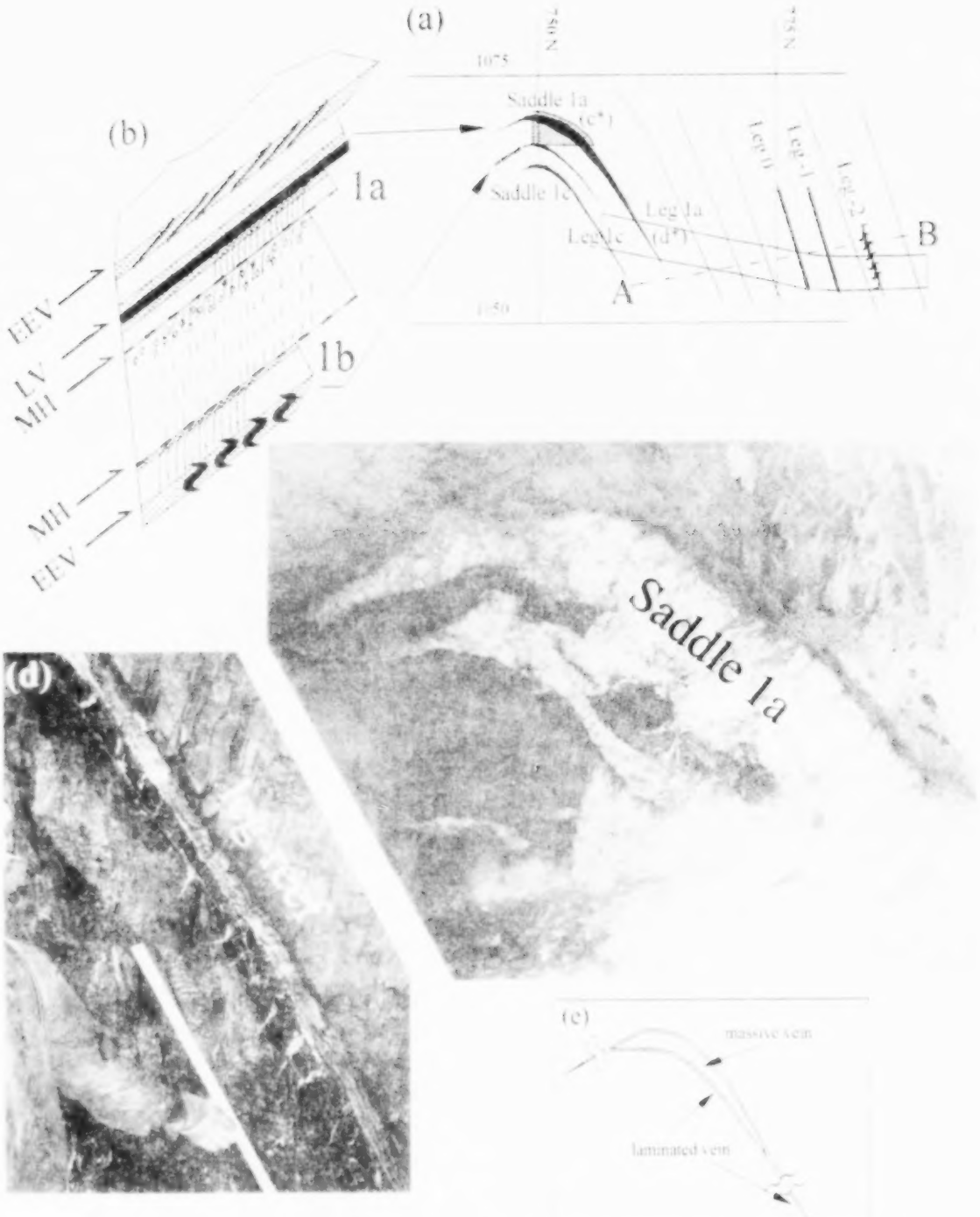

Figure 5. (a) Section at 2400 E showing fold geometry and distribution of saddle-reefs 1a-c and leg-reefs of stratigraphically higher saddle-reefs (Legs 0, -1, -2). Letters with * (e.g. c*) indicate the location of corresponding photograph. (b) Enlargement of a stratigraphic interval of the south limb, including saddle-reef 1a and 1b. Flexural shear structures within slate intervals include en echelon veins (EEV), movement horizons (MH), and laminated veins (LV). (c) Photograph of saddle-reef 1a showing the highly asymmetric geometry, see (b) for location. (d) Photograph of the leg-reef of saddle-reef 1a on the north limb. The leg consists of mainly laminated veins with en echelon veins formed in foot wall slate. Movement horizons are common within the slate with some minor displacement of en echelon veins is recorded, see (b) for location. (e) Schematic diagram of saddle-reef 1a showing the general distribution of massive and laminated veins within the saddle- and leg-reefs.

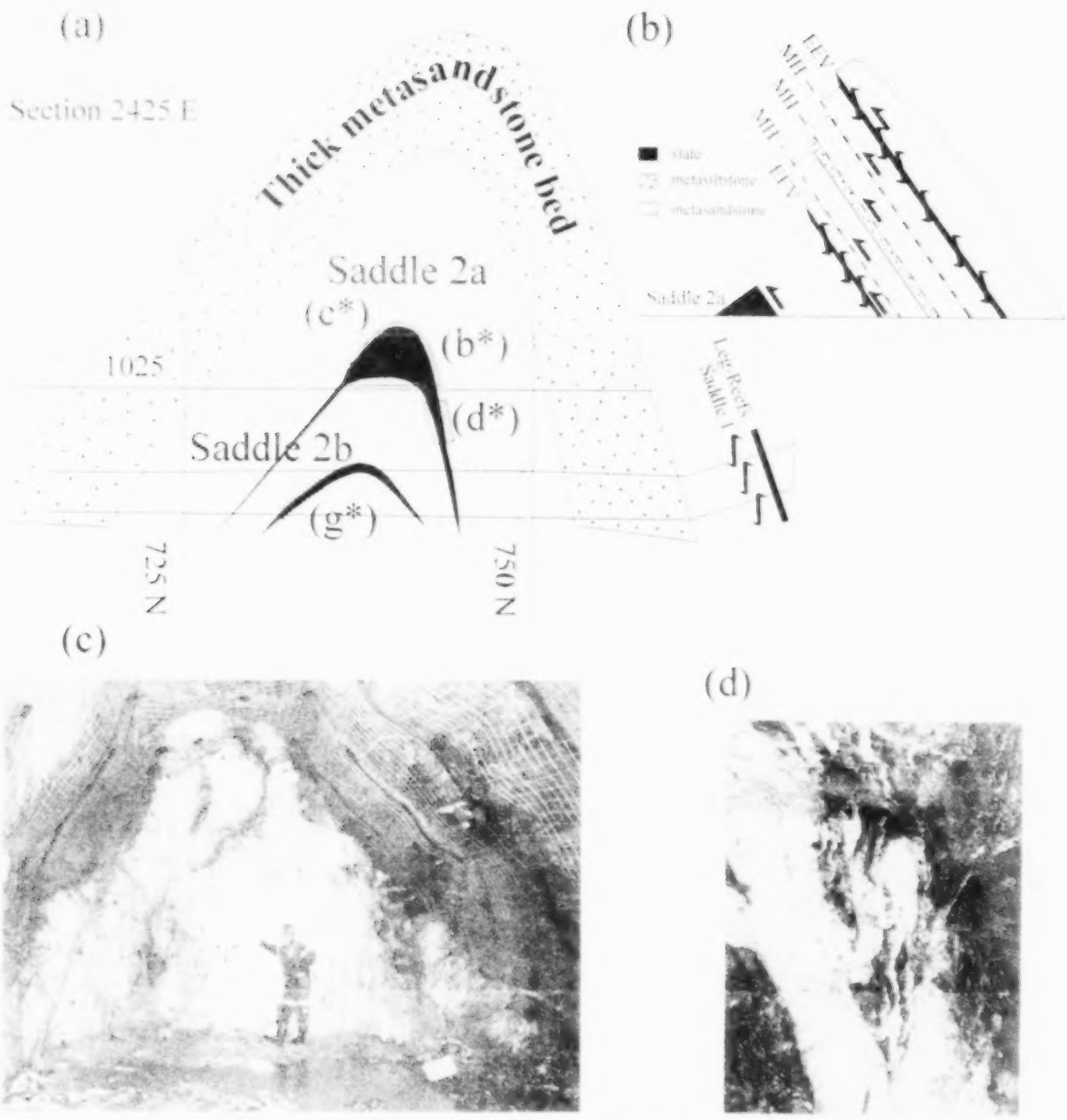

Figure 6. (a) General cross-section of saddle-reef 2 at 2425 E. Letters with * (e.g. b*) show the locations of Figures 6b-g. (b) Section of the hanging wall of saddle-reef 2a showing the distribution of en echelon veins (EEV) and movement horizons (MH) within slate and metasiltstone intervals. (c) Photograph of saddle-reef 2a at approximately 2250 E. (d) Photograph of the north leg-reef of saddle-reef 2a at approximately 2325 E. The vein consists of a massive, coarsely laminated bedding-parallel vein (BPV) and a zone of strongly sheared (boudinaged) en echelon veins (EEV) in the hanging wall.

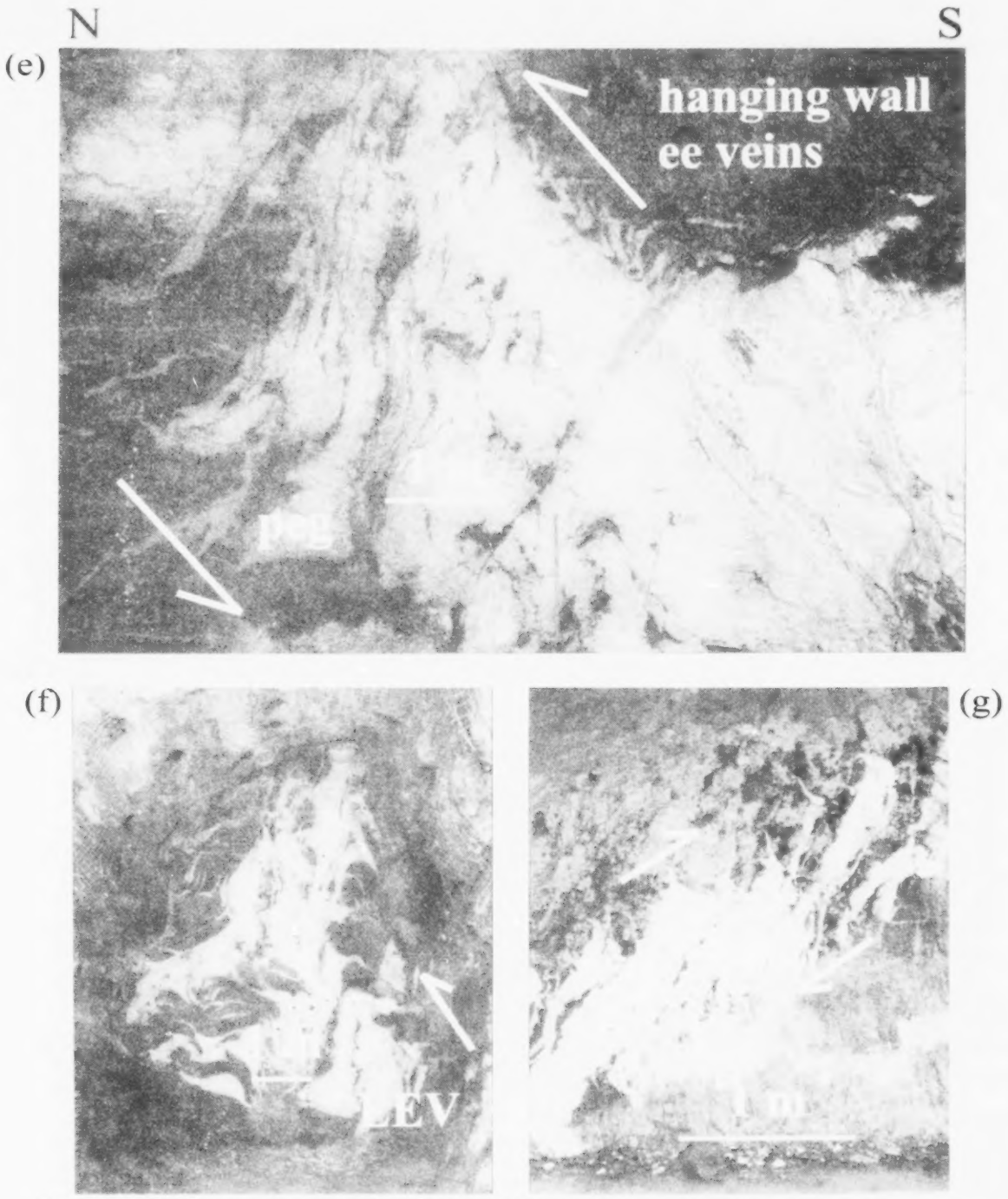

Figure 6. (cont'd) (e) Photograph of saddle-reef 2a at 2380 E. The saddle-reef at this location consists principally of large amalgamated en echelon veins separated by septa of slate on the north part of the hinge. Vein geometry is consistent with flexural shear on the north limb. Note the zone of small en echelon veins in the hanging wall of the north limb showing a similar sense of shear. (f) Photograph of saddle-reef 2a at 2600 E. The saddle-reef at this location is complex, but includes large en echelon veins (EEV) on the north side; dotted line traces the sigmoidal form of an en echelon vein. (g) Photograph of the south leg-reef of saddle-reef 2b, which consists of closely amalgamated, strongly sheared en echelon veins.

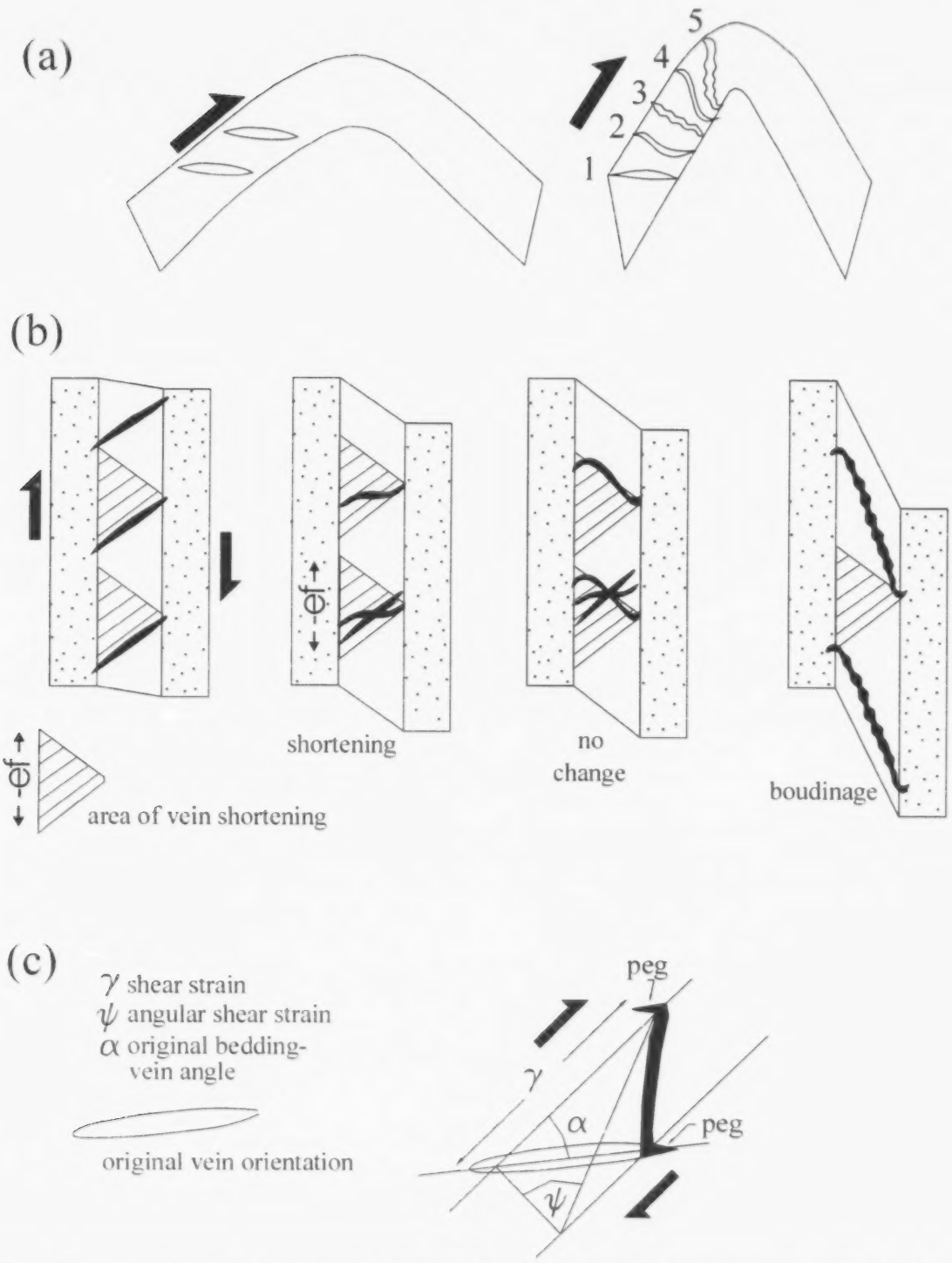

Figure 7. Diagrams showing the formation and progressive deformation of en echelon veins on a fold limb (a) (after Ramsay and Huber, 1987) and in a general shear zone (b) (after Ramsay and Huber, 1983). (c) Sketch showing the shear strain recorded by deformed en echelon veins. Note that the original orientation of the vein to bedding (α) is determined from the pegs within metasandstone.

the structurally highest, as saddle-reef 1a, 1b and 1c (Figs. 2b, 5a). Due to the closeness of the saddle-reef veins, only saddle-reef 1a was mined, although development work has locally exposed all three saddle-reefs. Saddle-reef 1a is asymmetric with respect to the fold, defining a crescent-shaped vein extending from the fold hinge down the north limb (Fig. 5c). The maximum thickness is 1.3 m. The saddle-reef vein is composite, consisting of mainly massive (locally vuggy), quartz with laminated quartz occurring at the margins (Fig. 5e). The saddle-reef progressively tapers down the north limb and, within approximately 10 m, is represented by a thin (~6 cm) laminated bedding-parallel vein and minor en echelon veins (Fig. 5d). On the south limb, the saddle-reef is represented by a laminated vein starting at the fold hinge. The massive quartz invariably cross-cuts the laminated vein, suggesting a history of laminated vein formation followed by emplacement of massive quartz. Movement horizons occur at the hanging wall contact of the vein and a significant shear zone, including en echelon veins and movement horizons, is locally developed in the hanging wall of the south limb. Some movement horizons on the south limb are defined by 1-2 cm thick zones of fault gouge (clay) with angular quartz clasts. This shear zone and related en echelon veins may be analogous to the "leather jacket" structures defined in the Victoria deposits of Australia (Baragwanath, 1953; Hodgson, 1989). Significant arsenopyrite (a few percent) occurs as coarse crystals and clots within the vein and is disseminated throughout the adjacent wall rock.

Saddle-reef 1b is locally exposed and is relatively thin (max. 20 cm). The leg-reef on the south limb consists of en echelon shear veins right up to the hinge zone. Saddle-reef 1c is locally exposed in a crosscut. This saddle-reef is similar to saddle-reef 1a in size and geometry: it has a maximum thickness of approximately 1 m and is asymmetric, defining a crescent-shaped structure which extents from the hinge down the north limb. Laminated veins occurs at the margins of the predominantly massive quartz saddle-reef vein. On the north limb, the leg-reef vein is defined by massive bedding-parallel vein and en echelon shear veins.

Saddle-reef veins 1a, 1b and 1c occur within slate intervals and their leg-reefs are interpreted to represent flexural shear structures. Abundant evidence of flexural shear is found in slate horizons adjacent to the leg-reefs of these saddle-reefs (Figs. 5b). The leg-reefs of saddle-reefs 1a and 1c are observed at significant distance down the north limb (exposed at the ~1060 level, Fig. 5a, and the 1020 level, Fig. 6a), represented by laminated bedding-parallel veins and (or) en echelon shear veins.

Saddle-reef 2

Saddle-reef 2 includes two saddle-reef veins, referred to as 2a and 2b (Fig. 6a). Saddle-reef 2a is larger and was mined for approximately 500 m along strike (Fig. 2c). Exposures of saddle-reef 2b are restricted to the leg-reefs.

Saddle-reef 2a Saddle-reef 2a is large, measuring approximately 4+ m in height and 4+ m across the base (e.g. Fig. 6c). The saddle-reef vein consists mainly of massive quartz with variable amounts of slate inclusions. The general shape is triangular, being defined in general by bedding. However, this saddle-reef is also strongly asymmetric, with a thick leg-reef extending down the north limb, whereas only a minor leg-reef extends down the south limb. The saddle-reef occurs within a slate-metasiltstone interval, commonly with black slate in the hanging wall of the vein and a distinct laminated metasiltstone in the foot wall. En echelon shear veins invariably occur in the hanging wall slate on the north limb (e.g. Figs. 6 d, e) and locally define the south limb of the saddle-reef.

The saddle-reef is variable in character and geometry along strike (Figs. 6c, e, f), most notably in the amount of slate wall rock. In general, the amount of quartz progressively decreases to the east. Figure 8e, from just east of fault 1 (line 2400 E), shows the saddle-reef to consist of a series of closely spaced, amalgamated, strongly sheared en echelon veins. The geometry of the individual en echelon veins is evident, defined by horizontal pegs and vertical (sheared) segments separated by septa of slate wall rock. A series of smaller scale en

echelon veins occurs in the hanging wall of the north limb, consistent with this saddle-reef elsewhere. Figure 6f shows saddle-reef 2a at approximately section line 2600 E. The "saddle-reef" at this location is complex, but includes large en echelon veins. Note a zone of vertical, boudinaged (en echelon?) veins in the top centre of the saddle-reef zone.

Leg-reef 2a Mining of the north limb of saddle-reef 2a has provided good exposure of the north leg-reef of this saddle-reef. The leg-reef tapers from about 2 m thickness at the base of the saddle-reef to 10-20 cm at a distance of aproximately 7 m down the limb. The leg-reef consists of a massive, coarsely laminated (widely spaced slate? bands parallel the vein margin), bedding-parallel quartz vein with a zone of en echelon shear veins in the hanging wall (Fig. 6d), similar to the main saddle-reef vein. The en echelon veins are strongly boudinaged, reflecting high shear strain. Discordant veins are abundant in the foot wall of the saddle- and leg-reef; however, they do not cross-cut the latter or occur in the hanging wall. Arsenopyrite is common (few percent) within the vein and wall rock. Coarse gold is common and is generally associated with galena in the leg-reef.

Leg-reef 2b Saddle-reef 2b is not exposed, although both the north and south leg-reefs of this saddle-reef are exposed in the ramp at an elevation of 1016 m (Fig. 6a). These legs reefs are variable in character, and include laminated bedding-parallel veins (cf. Fig. 5d), massive bedding-parallel quartz veins, and en echelon shear veins. Exposure of the south leg-reef on the east wall of the ramp is particularly notable, consisting of a wide zone (approximately 1 m) of closely spaced (amalgamated) and boudinaged en echelon shear veins (Fig. 6g).

Saddle-reef 3

Exposure of the third saddle-reef structure is limited, with less than 50 m of development on this structure to date. Diamond-drilling suggests there are two saddle-reef veins, 3a and 3b (Fig. 2b); however, only one, presumed to be 3a, is exposed and described here. The hinge zone at saddle-reef 3a defines a broad open arch structure (Fig. 8a, b) and the saddle-reef vein occurs within a metasilt-stone-slate interval, with the vein typically hosted by black slate. Saddle-reef 3a displays asymmetry similar to saddle-reef 1 and 2, with the thickest part of the vein on the north limb (Fig. 8b). The saddle-reef is about 40 cm thick at the hinge, where it locally bifurcates, and thickens slightly on the north limb to approximately 50 cm. Extension down the north limb is not exposed but it is presumed to maintain this thickness for some distance based on comparison with, for example, saddle-reef 1 (Fig. 5c). The saddle-reef thins quickly to the south, where it consists of a laminated vein. The saddle-reef vein includes a laminated vein, which displays some buckling, along the vein margin, with massive quartz forming the bulk of the vein. Arsenopyrite is very abundant, occurring as disseminated crystals and massive clots within the vein and disseminated throughout the wall rock.

Development of Saddle-reef Veins

Formation of saddle-reefs, leg-reefs and related veins in chevron folds is well understood; such veins are associated with structures related to flexural-shear on the limbs and associated hinge zone dilation (e.g. Chace, 1949; Ramsay, 1974; Hodgson, 1989). Saddle-reef veins are often considered in isolation, particularly in discussion of saddle-reef deposits. Additionally, the saddle-reef model is generally presented in the simplest of forms, with development of a triangular void in the hinge of an upright fold, which has experienced a simple history of amplification without hinge migration (Ramsay, 1974). However, fold histories are generally not simple and several structures are known to result from the development of chevron folds simultaneous with classic saddle-reef voids (e.g. Chace, 1949, Ramsay, 1974, Tanner, 1989). Precipitation of quartz in these various structures results in a family of saddle-reef and related veins.

The structure and vein system at the EnvioGold Dufferin gold deposit is readily explained in a flexural-folding, saddle-reef environment. Movement horizons, laminated veins and en-echelon veins are pervasive features, occurring within most slate intervals, and display a movement direction and shear sense consistent

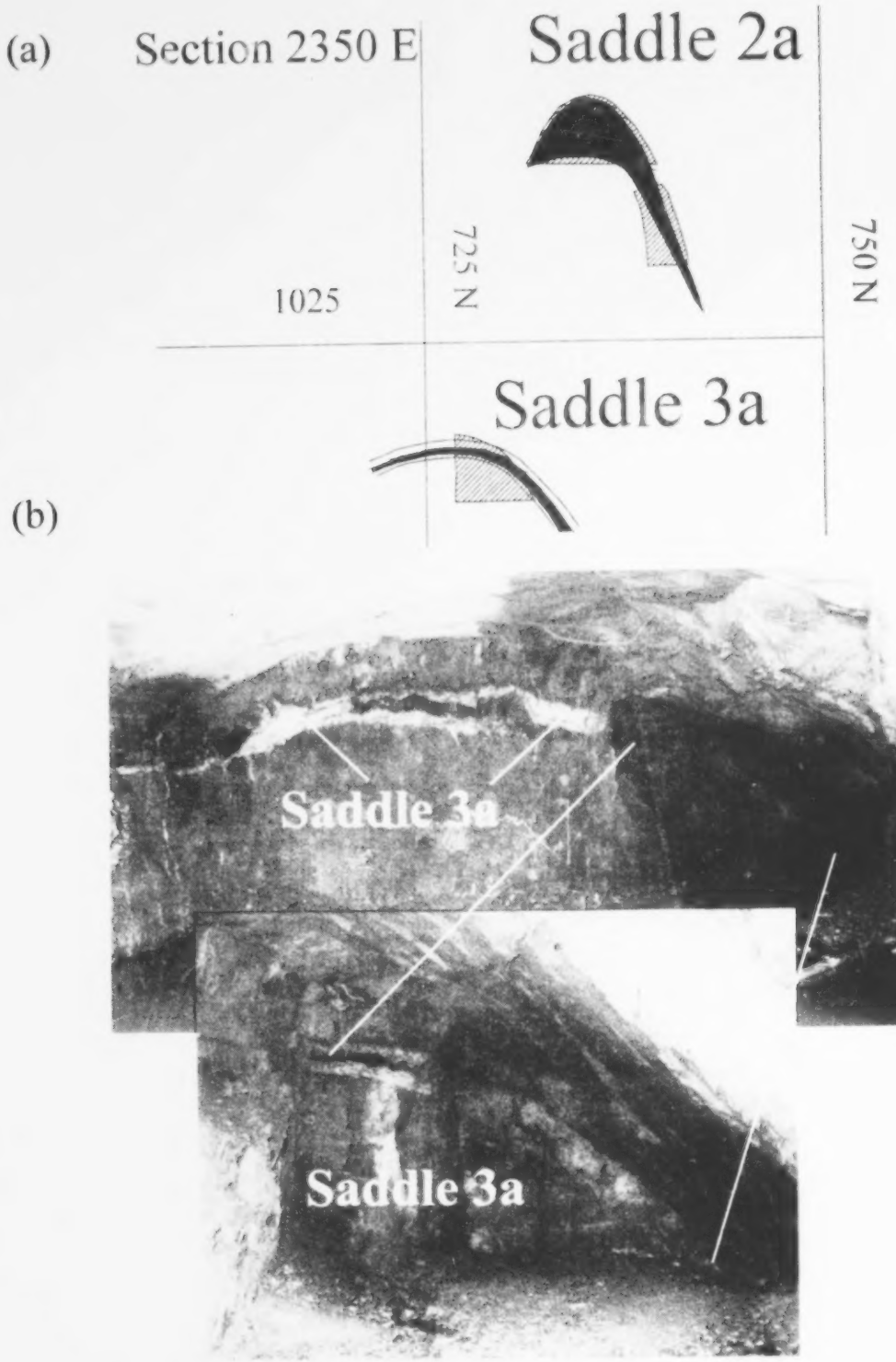

Figure 8. (a) Section at 2350 E showing the geometry of saddle-reef 3a. (b) Photograph of saddle-reef 3a. Inset photograph is a close-up of the north part of the hinge zone and north limb.

with flexural folding. Leg-reef veins in particular are clearly associated with structures resulting from flexural folding and display evidence of syn-folding emplacement (e.g. en echelon shear veins), and a clear connection exists between leg-reefs and saddle-reefs. The various veins occur along common structures and vein relationships suggest synchronous emplacement of all veins. Laminated veins are invariably cut by massive veins, consistent with laminated veins recording the initial shear preceding development of dilational structures filled by massive quartz. The high shear strains recorded by en echelon veins imply that these structures record significant fold amplification. However, shear strain is focused within thin slate layers and large shear strains occur for small changes of limb dip when initial limb dips are high (Ramsay, 1974). Therefore, the shear strain recorded by en echelon veins could reflect a small increment of fold tightening late in the fold history (cf Horne and Culshaw, 2001). Although the saddle-reef veins represent thickened reefs in the hinge zone, they display characteristics which vary from a simplistic saddle-reef model. Two notable differences include (1) the asymmetry of saddle-reef veins and (2) the significant contribution of en echelon veins to saddle-reef veins.

En Echelon Saddle-reef Veins

En echelon veins are common within the deposit and it has been noted that saddle-reef veins are, at least locally, composed largely of en echelon veins. Saddle-reef 2a, in particular, is locally dominated by large en echelon veins which, for the most part, display a sense of shear consistent with flexural-shear on the north limb (e.g. Fig. 6e). The dominance of en echelon veins in the hinge zone indicates that much of the volume recorded by the veins results from shear, in contrast to saddle-reef voids, and that flexural-shear on the limbs extended into the hinge zone. Tanner (1989) and Ramsay (1974) illustrate extension of flexural-slip movement horizons with associated en echelon veins into, and across, the fold hinge along hinge thrusts (Fig. 9a,b) and the spur veins and leather jacket vein arrays in the Australian deposits reflect bedding-parallel faults which extend beyond the hinge, locally connecting with bedding-parallel movement horizons in adjacent folds (Hodgson, 1989). Development of these structures may reflect "accommodation structures" resulting from variation in thickness of competent layers (Fig. 9b; Ramsay, 1974) or formation of conjugate faults accommodating post-folding shortening.

There is significant variation in bed thickness (note the anomalous thick metasandstone bed above saddle-reef 2a, Fig. 6a) so that "accommodation structures" would be expected. However, the saddle-reef veins within the deposit are generally stratabound and there is no clear evidence of cross-cutting thrusts in the hinge zone. Indeed, the en echelon veins in the hinge do not pass the fold hinge and, furthermore, the en echelon veins in the hinge (saddle-reef) are an extension of those on the limb (leg-reef). The thick zone of en echelon veins in the hinge region may simply reflect thickening of the slate layers in the hinge zone, typical of chevron folds (Ramsay, 1974). Flexural shear strain is restricted to slate horizons. Therefore, as slate layers hosting en echelon veins thicken towards the hinge zone, the size of the en echelon veins increases accordingly (Fig. 9c).

Saddle-reef Asymmetry

As outlined above, the saddle-reef veins have a pronounced asymmetry, with saddle-reef development mainly in the hinge and north limb of the fold. Similar asymmetry was noted in Australian deposits by Chace (1949), although no explanation was provided. For saddle-reef 2a, where en echelon veins are an important component, the asymmetry may simply reflect variance in the shear strain between limbs. This variance in shear could reflect variance in limb length and/or limb dip; the north limb is both shorter and steeper than the south limb. However, this is not apparent for saddle-reefs 1 or 3, where the proportion of en echelon veins is less apparent. The massive and vuggy quartz that constitutes the saddle-reef is interpreted to have formed within structurally developed dilation zones and, therefore, saddle-reef asymmetry is a question of asymmetric dilation.

Asymmetry of the saddle-reefs may also reflect profile shape changes of the fold during fold development. Fowler and Winsor (1996) present several potential shape changes based on experimental modelling of chevron fold development and evaluation of profiles of several chevron folds hosting saddle-reef vein systems (Fig. 9d). They have shown that vertical dilation in the flat segment of a box fold results from limb steeping (Fig. 9e). Saddle-reefs formed in this environment could be transformed onto a limb by fusion of the median segment of the box fold with a limb (Fig. 9e). This explanation is not supported by the en echelon veins in the hanging wall of the saddle-reef, which show opposite sense of shear on either side of the existing fold hinge. However, these veins may record the late shear associated with box fold to chevron transition. The contribution of profile shape change during folding to the asymmetry of the saddle will be better understood with exposure of additional saddle (fold hinges) at depth.

Comparison with Central Victoria

The vein system of the EnviroGold Dufferin deposit is similar to saddle-reef deposits of central Victoria, Australia. Chace (1949) described the Australian vein systems as including saddle-reefs, leg-reefs, neck-reefs and spurs associated with bedding-parallel faults, dilation in the hinge, and dilations associated with faults. The veins are composed of massive and laminated quartz, quartz breccia and brecciated quartz, and the distribution of laminated and massive quartz is similar to the EnviroGold Dufferin deposit: laminated quartz is restricted to leg-reefs and the margins of saddle-reefs. En echelon veins, referred to as "leather jackets" in Australia, are documented along limb thrusts associated with the saddle-reef veins (Baragwanath, 1953).

Age of Veins

$^{40}Ar/^{39}Ar$ ages of 388 Ma and 403 Ma, obtained for slate within and adjacent to veins in the portal area of the EnviroGold Dufferin deposit, have been interpreted to reflect metamorphism (Kontak *et al.*, 1998). No isotopic dating of the veins has been attempted. However, $^{40}Ar/^{39}Ar$ ages for vein minerals in other Meguma gold deposits of ca. 370 Ma are consistently younger than $^{40}Ar/^{39}Ar$ ages for whole-rock samples from the same deposits, which record metamorphism (Kontak *et al.*, 1998). This has been interpreted to indicate a post-metamorphic age for vein emplacement (Kontak *et al.*, 1998). Horne and Culshaw (2001) also proposed a post-metamorphic age for vein emplacement, which they relate to a late, flexural-slip re-activation of earlier flexural-flow folding.

Several features support a late-folding age for vein emplacement at the EnviroGold Dufferin deposit. Saddle-reefs only develop after significant limb amplification, and formation of flexural shear and saddle-reef structures is accelerated with shortening (Ramsay, 1974). The maturity and pronounced development of the saddles suggest significant fold development at the time of vein emplacement. Flexural shear structures are largely brittle (en echelon gash veins, movement horizons) and clearly deform fold-related cleavage.

Distribution of Gold

Gold was not often noted in the mine and relatively few analytical data are available; thus, the distribution of gold within the deposit is not well understood. However, the following observations can be made. Gold (i.e. visible gold and/or assay results) has been detected within all vein types, including saddle-reef, laminated leg-reef, en echelon and discordant veins. This is consistent with the interpretation of synchronous formation of all veins. The most consistent, and abundant, visible gold was noted in the north leg of saddle-reef 2a, where it commonly occurs near slate septa within the vein. Throughout the deposit there is an apparent positive correlation between visible gold and galena: gold generally occurs within a few centimetres of galena and locally gold decorates galena. Sphalerite is also common near gold in some samples, although less recognizable in the mine. Gold is found decorating arsenopyrite; however, the abundance of arsenopyrite offers no apparent guide to concentrations of gold. Arsenopyrite is common to abundant within all vein types and is disseminated in the adjacent wall rock as a zone of wall rock alteration. Low gold levels occur in wall rock adjacent to veins.

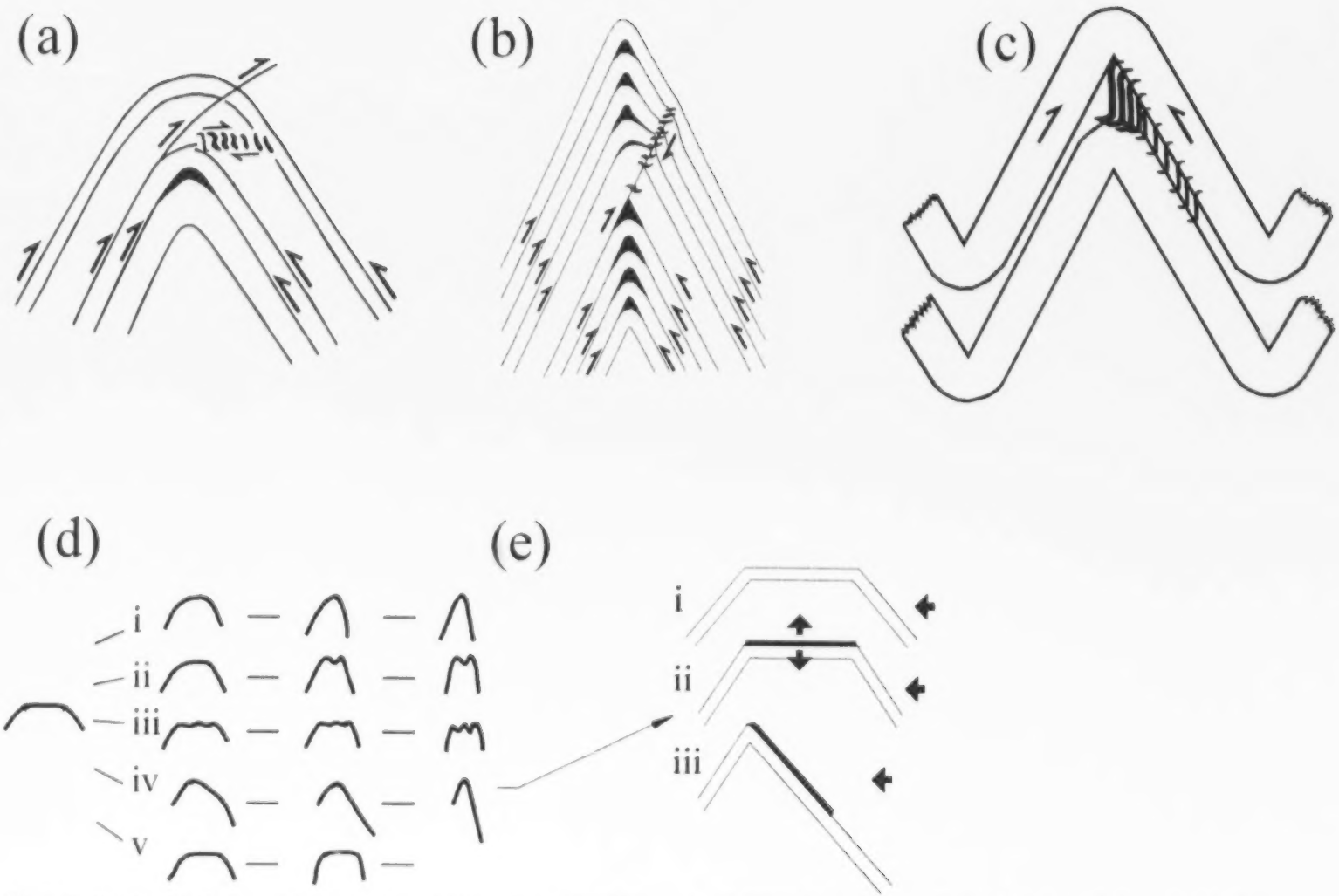

Figure 9. Sketches (a, b) showing the extension of bedding-parallel movement horizons across the fold hinge with associated en echelon vein: (a) after Tanner (1989) and (b) after Ramsay (1974). (c) Schematic diagram showing the extension of en echelon veins from a limb into the hinge, where they increase in size in response to increasing thickness of the slate interval. (d) Diagram showing possible profile shape change during the transition of box folds to chevrons (after Fowler and Winsor, 1996). (e) Close-up of profile shape change iv in (d) showing the formation of dilation in the hinge (solid black, representing saddle-reef) during limb steepening from stage i to ii, and transition of the median segment of the box fold onto a limb during further shortening, resulting in an asymmetric saddle-reef vein.

Much more work is required in order to evaluate the gold distribution and controls on mineralization within the deposit. The association of gold with the vein array supports a genetic relationship; however, secondary features of a chemical or structural nature may well control the distribution and abundance of gold within the vein system

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Internal Stratigraphy of the Jurassic North Mountain Basalt, Southern Nova Scotia

D. J. Kontak

Introduction

The Jurassic (201 Ma, Hodych and Dunning, 1992) North Mountain Basalt (NMB; also referred to as the North Mountain Formation) forms a prominent cuesta along the southern coastline of the Bay of Fundy. These continental, tholeiitic basalt flows have played an important role in the geological heritage of the province by: (1) hosting some of the earliest mineral resources exploited (e.g. Cu, Fe), (2) contributing to the character of zeolite mineralogy (e.g. type locality for mordenite; How, 1864), (3) forming part of the Fundy Rift Basin, an important part of the Mesozoic evolution of eastern North America, and (4) filling an important niche in the aggregate operations of the province. Despite the importance of the NMB there has been relatively little recent work devoted to defining and extending the stratigraphy of the basaltic flows along the length of the Annapolis Valley and addressing some important questions that are apparent from such work. This paper is, therefore, a summary of recent and continuing efforts to establish a working stratigraphy that may be applied to the NMB, and should be considered, as such, a work in progress.

General Geology

The North Mountain Basalt (NMB) comprises an Early Jurassic (Hettangian) sequence of basalts that formed in the Fundy Rift Basin (i.e. failed aulacogen), part of the Newark Supergroup of 16 syn-rift basins of Middle Triassic to Early Jurassic age related to the incipient breakup of Pangea. The rocks underlying the NMB are red to pale green-grey, fluvial-lacustrine siltstone and shale of the Late Triassic Wolfville and overlying Blomidon formations, whereas the overlying rocks are lacustrine limestone of the Scots Bay Formation and time equivalent, fluvial-lacustrine red siltstone and shale of the McCoy Brook Formation. Whereas upwards of 250 m of McCoy Brook Formation sediments are exposed, only 9 m of Scots Bay Formation remain as remnant inliers along the Scots Bay coastline (De Wet and Hubert, 1989).

The NMB outcrops along the Bay of Fundy in southern mainland Nova Scotia and is exceptionally well exposed along the coastline and inland along river valleys (Fig. 1). Topographic relief of the area bounding the Bay of Fundy reflects the distribution of the underlying massive basalt flows. No more obvious is this than along the Annapolis Valley area where the west side of the valley is composed of massive, fresh basalt of the lower flow unit of the NMB. The proximity of the area on the north side of the Bay of Fundy to the east-west Cobequid-Chedabucto Fault Zone has resulted in structural modifications to the otherwise simple stratigraphy of the NMB. For this reason, studies were primarily confined to relatively undisturbed sections along the southern coastline of the Bay of Fundy in Nova Scotia.

Methodology

The present study represents part of an ongoing examination of the nature of the NMB and associated zeolite mineralization (Kontak, 2000; DeWolfe *et al.*, 2001; Kontak *et al.*, under review). The area from Cape Split to Freeport (Fig. 1) has been examined in varying detail over the past three years and, in addition, drill core has been logged and detailed petrographic and petrological studies have been undertaken. Although not reported in detail here, integration of digital elevation modeling (DEM), using the provincial database, with field-based information appears to offer promise and is currently being explored further. Collectively, therefore, the study is focused at furthering our understanding of the nature of the NMB, the distribution of the different flow units, the characteristics of these units, and the mineral and aggregate potential of these rocks. In this paper the implications of continuing work are used to

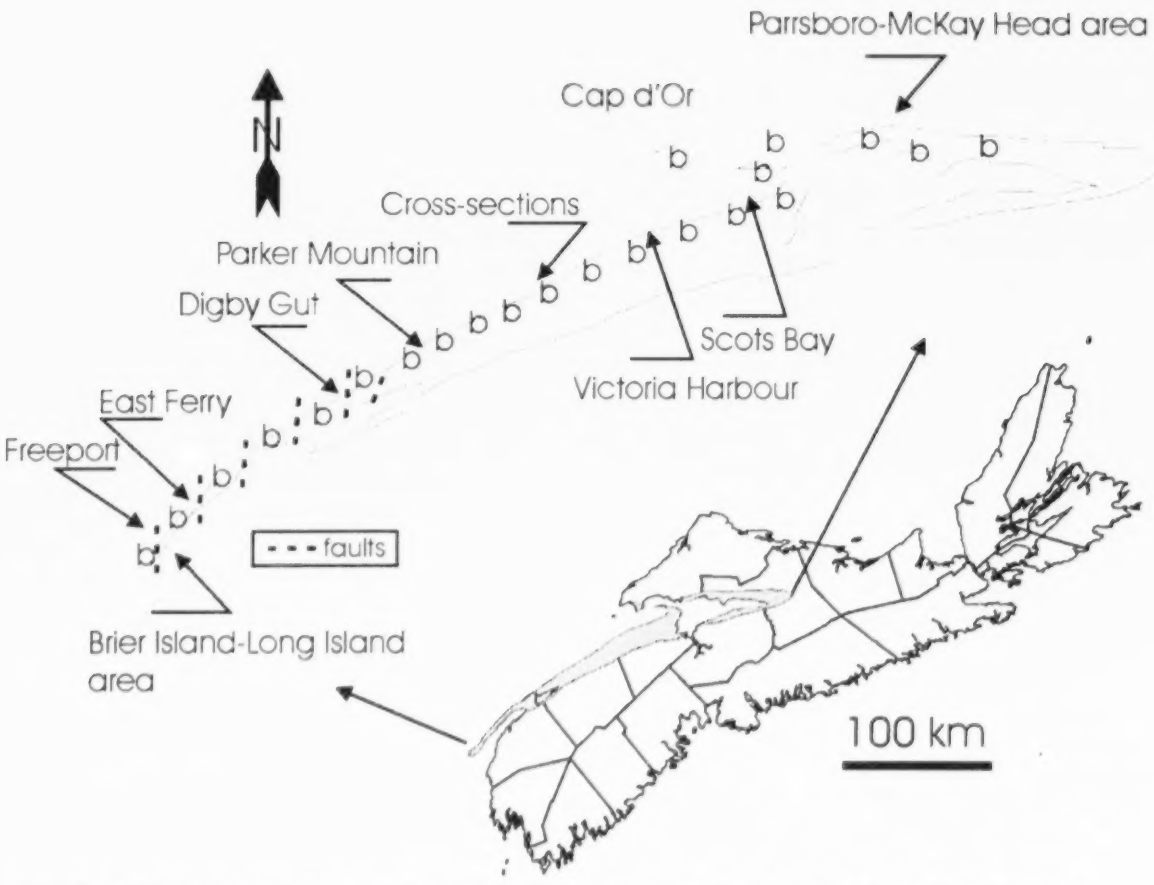

Figure 1. Map of Nova Scotia showing the outline of the Triassic-Jurassic rocks, with the North Mountain Basalt indicated as b symbol. The locations of relevant areas referred to in the text are indicated for reference.

examine the internal stratigraphy of the NMB, which may form a basis for further, more detailed geological studies in other parts of the unit.

Previous Work

The regional mapping of Hudgins (1960), extending from Digby Gut to Scots Bay, provided the first detailed modern account of the internal stratigraphy, albeit based in part on earlier workers. Hudgins (1960) recognized the following stratigraphy (Table 1) for the NMB, mostly based on a measured section around the Digby Gut area.

The area west of Digby, in particular Long Island and Brier Island, was mapped by Lollis (1959) and Koskitalo (1967), with several diamond-drill holes part of the exploration work of the latter author. These authors both recognized that the NMB could be conveniently subdivided into three units based on the nature of the flows. Lollis (1959) named these units the South Shore member (SSM), Middle member (MM), and North Shore member (NSM) for, respectively, the lower massive flow, the amygdaloidal middle flows, and the upper massive flow(s). Assigned thickness were 185 m, maximum of 92 m, and 154 m, respectively, based on sections measured in the East Ferry area. More recently, Mallinson (1986) measured a section along the west end of Long Island at Freeport and integrated information from a diamond-drill hole (Koskitalo, 1967) to provide the following stratigraphy.

(1) SSM - 112 m of massive basalt.

(2) MM - four flows of 1.5 m to 2.5 m at Ronnie' Point, but seven flows of 3.3 m to 9 m in

Table 1. Stratigraphy of the North Mountain Basalt measured along a coastal section at Digby Gut (after Hudgins, 1960).

Flow	Thickness	Comment
Top flow	9+ m	greenish black to greyish black, columnar jointed
Second flow	11+ m	greyish black, massive flow
Intermediate flows	20+ m	varying thickness, fine grained, zeolite bearing
Intermediate flows	51+ m	undetermined individual thickness, zeolite bearing
Bottom flow	90+ m	greenish black to greyish black, columnar jointed

drill core with maximum thickness of 41 m. This rapid change in flow number and thickness characterizes the MM, as also noted by Mallinson (1986) and observations of the writer.

(3) NSM - 61 m of massive basalt.

In addition, mapping by these authors, in conjunction with the impressive topographic profile of the land, indicated that the three-fold subdivision could be extended at least to the Digby area (Fig. 1). However, extrapolation of the stratigraphy eastward remained a problem and the present study is focused, therefore, on addressing this problem. In addition, the nature of the complex flows that constitute the MM is discussed.

The most recent mapping of the NMB was carried out by White *et al.* (1999) during regional mapping (i.e. 1:50 000 scale) of southwestern Nova Scotia. Due to the scale of this mapping, detailed subdivision of the NMB was not possible.

Stratigraphy and General Features of the North Mountain Basalt

Based on the previous work discussed above, field observations of the writer, and additional work of Greenough *et al.* (1989), a proposed stratigraphic framework for the NMB is presented in Figure 2. In this diagram the terms lower, middle and upper flow units are used as proxies for the terms of Lollis (1959). With respect to this figure, the following points are noted, commencing from the base upwards.

(1) There is very little known about the relationship of the basal flow contact with the underlying sediments, either Triassic or older. Locally there are areas of intense bleaching and clay alteration (Hudgins, 1960; White *et al.*, 1999; D. Kontak, personal observations), but the extent and significance of such zones remains unconstrained and requires attention. An important aspect of the basement rocks to the NMB is their paleotopography at the time of basalt eruption. Given the fluvial-deltaic nature of the deposits, it is assumed that the overall landscape at this time was generally flat.

(2) The basal or LFU varies in thickness from 40 to 185 m. As will be discussed below with reference to cross-sections, this variation is real and probably very abrupt, and must relate to pre-flow, possibly structurally controlled topographic variation, despite what the nature of the basement sediments may imply in general. All previous workers have inferred that the LFU represents a single homogeneous unit. The LFU is completely exposed at Parker Mountain quarry near Annapolis Royal, where the unit appears as a uniform textured, massive, holocrystalline basalt with well developed columnar jointing and without any apparent break in the exposed section. Well exposed sections of the LFU at East Ferry (Figs. 3, 4 of Lollis, 1959) and McKay Head (Greenough *et al.*, 1989; Greenough and Dostal, 1992) display mafic pegmatite (dolerite of Lollis, 1959) and rhyolite bands in the upper part of the unit.

(3) The MFU varies in total thickness, number of flows, and thickness of the individual flows along the strike length of the NMB. In the McKay Head-Parrsboro area, the flows are consistently thicker than in the Annapolis Valley, but there are fewer

	McKay Head-Parrsboro	Valley	Digby	East Ferry	Freeport
	Greenough et al., 1989	this work	Hudgins, 1957	Lollis, 1959	Mallinson, 1986
UFU	McCoy Brook Fm. ????????	Scots Bay Fm ? thickness	20 m, 2 flows	154 m, 2 flows	>61 m, 1 flow
MFU	75 m, 4 flows - McKay Head ≥50 m, 4 flows - Cape D'Or	150-165 m 15 flows	>71 m, several flows	92 m, several flows	9-41 m, 4-7 flows
LFU	≥90 m - Economy Mtn. ≥175 m - McKay Head ≥150 m - Cape D'Or	40-80 m - 150 m, 1 flow	>90 m, single flow	185 m, single flow	112 m, 1 flow
Basement	Carboniferous or Triassic sediments	Triassic	Triassic	Triassic	Triassic

Figure 2. Summary of stratigraphy of the North Mountain Basalt around the Bay of Fundy coastline from Parrsboro to Freeport. Source of information for each area is indicated on the top of the section.

flows. There appears to be a thinning of the MFU toward the southwest in the Freeport-Brier Island area. The internal complexity of this unit is addressed in more detail below.

(4) The UFU is best exposed west of Digby, where the prominent ridge along the north side of Long Island and Brier Island is underlain by this unit. Exposure of this unit may relate to dextral offset along northeast-trending faults at several locations between Brier Island and Digby Gut (Fig. 1). This unit can be subdivided into a lower and upper part based on the presence of columnar jointing in the base and a more massive textured upper part with a honeycomb network of silica veins. This subdivision has been variably interpreted to represent a single flow with internal variation or two separate flows. Further work is required to reconcile this problem.

(5) There is an apparent absence of UFU basalt along the north shore of the Minas Basin and, at present, the reason for this is not really known. The presence of a disconformity at McKay Head, with a weathered veneer (<1 m), of angular blocks of amygdaloidal basalt in a silty matrix sitting immediately below McCoy Brook Formation sediments, indicates neither a structural hiatus nor an extended period of uplift and erosion prior to deposition of the overlying sediments. Thus, it is possible that UFU basalt was never present along this part of the Fundy Basin.

(6) The MFU is overlain by Jurassic sediments of the Scots Bay Formation in the Annapolis Valley area and McCoy Brook Formation sediments along the north side of the Bay of Fundy. Interestingly, in the latter area there are abundant interflow sediments and sedimentary dykes within the MFU, whereas such features are much less abundant in the MFU along the Annapolis Valley.

Cross-sections of the North Mountain Basalt Formation

Several cross-sections (Fig. 3) traversing the North Mountain have been prepared using:

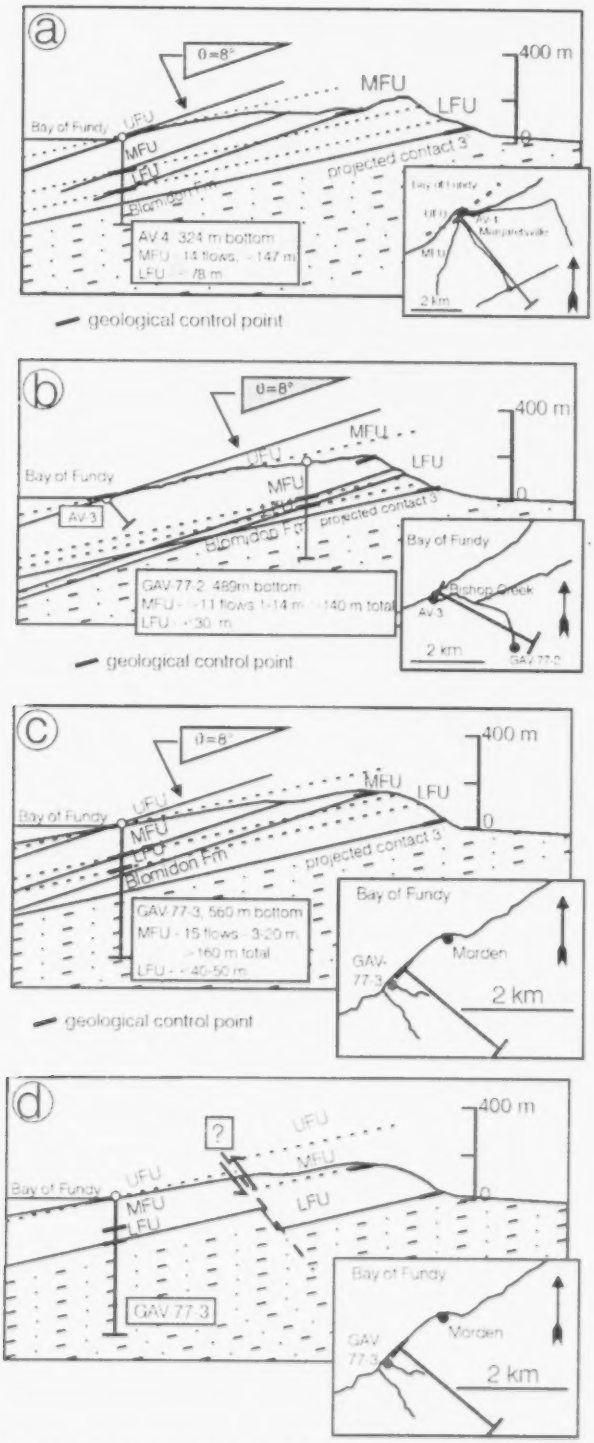

Figure 3. Cross-sections across the central part of the North Mountain Basalt in the Annapolis Valley area. Sm[illegible] inset diagrams locate the sections; see Figure1 for general locations. Sections constructed using the distribution of Triassic sedimentary rocks, outcrops along road traverses, and information from diamond-drill holes (AV-3, 4, GAV-77-2, 3). Note that the control points are indicated with short bold lines. The dip angles of 8° and 3° are used for purposes of discussion and inferring extent of the geology. Figure 3d is an interpretation of the geology of Figure 3c; note that there is presently no field evidence for the fault that is suggested as one possible interpretation of the geology.

(1) several drillholes collared in the MFU from exploration work in the 1960s and 1970s (Koskitalo, 1967; Comeau, 1978). These provide the best constraints on the regional dips of the basalt-sediment contact and internal dips between the flow units (LFU-MFU); and

(2) contacts between the UFU and underlying sediments, and between the different units of the NMB, as inferred from field relationships.

On these sections two dips have been used for extending contacts, 8° and 3°. The former dip represents a maximum for the range of 5-8° commonly quoted from observations of the flows themselves (e.g. Hudgins, 1960; Lollis, 1959; Mallinson, 1986), whereas the shallower dip of 3° is based on assumptions made from interpretation of the sections.

The following features are highlighted from the cross-sections in Figure 3.

(1) The regional dip of the NMB-sediment contact and flow unit contacts is close to 2-3°, which is much less than what is observed locally for flows themselves (see below).

(2) There is an inconsistency in the thickness of the LFU based on the inferred thickness of the exposure along the escarpment of the North Mountain (ca. 200 m) versus that determined from the drillholes (30-80 m). This inconsistency is apparent on all three sections suggesting, therefore, that there is a real variation of the unit thickness. This lateral change in thickness of the LFU on this scale was not previously recognized.

(3) The present relief of the North Mountain is attributed to the fact that the LFU is a massive, holocrystalline basalt. Had the LFU been composed of multiple amygdaloidal flows like the MFU, then the North Mountain would not be a prominent topographic feature due to its likely erosion, as has been the case for the MFU.

In order to accommodate the apparent regional variation in thickness of the LFU a preliminary interpretation of the Morden cross-section is presented in Figure 3d. It is proposed that pre-eruption faulting may have created a topographic depression of ca. 100-120 m, within which the LFU was deposited, thus accounting for its unusual thickness and textural uniqueness compared to the MFU and UFU (i.e. holocrystalline and lacking mesostasis). The extent of this northeast-trending fault feature is not known and there is no known manifestation of this in the field, or at least none that the writer is aware of. However, the presence of the fault relates to assuming that the overlying MFU is of uniform thickness to the southeast, which may in fact not be the case. If the MFU thinned out to the southeast, then the inferred displacement of the basement fault would not be required. Clearly, further work is required to resolve this dilema.

Internal Features of the Middle Flow Unit

Mapping of semi-continuous outcrop of the NMB along the southern Bay of Fundy coastline has indicated that the MFU has a complex internal stratigraphy and flow architecture. Given that the continuity of flows is important when trying to delineate a contained resource (e.g. zeolites), several areas have been examined in detail to demonstrate this complex architecture. A view of part of such a section of the MFU at Victoria Harbor is shown in Figure 4 where several important features are noted, namely: (1) the irregular contact between flows 1 and 2; (2) the pinching out of flow 2 against flow 1; and (3) the regular dip and thicknesses of both flows 3 and 4.

The results of mapping a multi-kilometre long section of MFU basalt from northeast of the wharf at Margaretsville (Fig. 3a for location) are summarized in Figure 5. From this section the following features are noted.

(1) Five flows can be followed along strike for 3.6 km. These same flows also continue to the southwest on the other side of Light House Point.

(2) The five flows are very irregular along strike, with pinch and swell features common. In some cases, the flow pinches out completely only to later re-emerge. Flow 3 in particular does this (point 1).

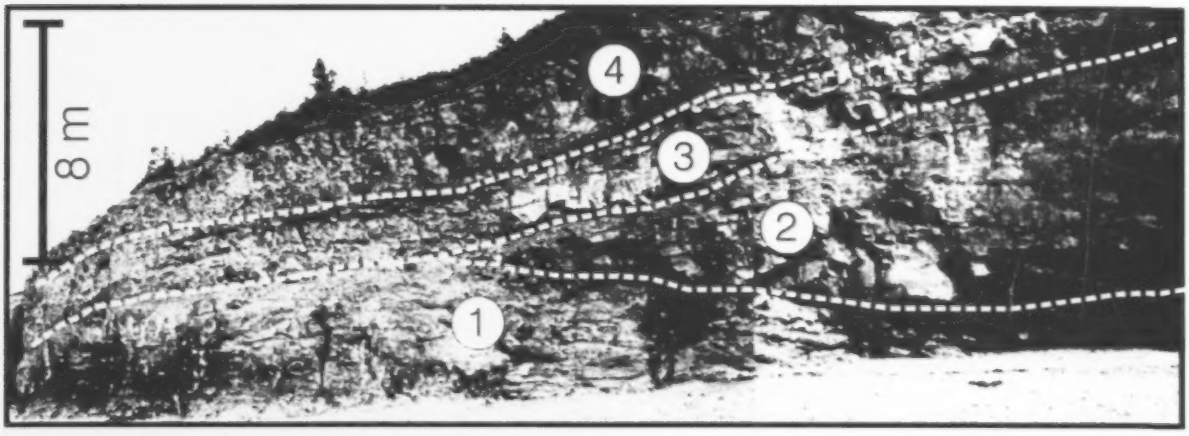

Figure 4. Photo mosaic of MFU flows at Victoria Harbour (facing southeast) showing occurrence of four basalt flows (numbered 1-4). Note that flow 2 pinches out to the northeast, but that it re-appears along the section.

(3) The presence of lava tongues between flows 2 and 3 (point 2) may indicate the presence of yet another flow not fully exposed in this section. These lava tongues are quite large, some 20-25 m width and 6-8 m high.

(4) Within the flows more complexity occurs, but on a smaller scale. This is best illustrated at point 3 of flow 4 where multiple thin flows constitute the unit (Fig. 6). Note that along strike this flow becomes a single, homogeneous flow with the same zonal distribution of vesicles noted in other flows (Kontak, 2001).

(5) Flow dips may be irregular (point 4), which suggests that the best indication of the overall dip is derived from the sections, as prepared in Figure 3.

(6) The north end of the section is less complex, with a consistent thickness for flows 2 and 4 that continues for several 100 m to the end of the area mapped. This consistency is similar to what is observed southwest of Light House Point, thus indicating that the degree of complexity seen in the flows of Figure 5 may be anomalous.

(7) Within any one flow there is commonly present the systematic distribution of vesicles and amygdules described for the NMB flows by Kontak (2000).

(8) Although accessibility prevented examining flow 1 in detail, it may represent the lower part of the UFU.

Discussion and Summary

The brief description and summary of the information presently available for the stratigraphy of the NMB indicates that there is much yet to be learned about this formation. In addition, there are several outstanding problems to be addressed, some of which follow.

(1) What is the origin of the LFU? Although it has been referred to as a ponded lava (Papezik *et al.*, 1988), are alternative origins likely and is a single outpouring of lava represented? Is the regional variation in thickness related to pre-flow faulting as a consequence of crustal thinning or extension? As indicated in the cross-sections (Fig. 3), there appears to be good reason to infer the presence of a northeast-trending fault within the basement to the NMB that may run parallel to the length of the valley for an unknown distance. Additional work using digital elevation data combined with imaging analysis may reveal if this feature does exist.

(2) The MFU is laterally variable with regard to the number of flows and their aggregate thickness. This is most clearly demonstrated in the McKay Head-Parrsboro area where only four flows are present, contrasting with the fifteen flows in the Annapolis Valley. Does this indicate separate vent sites?

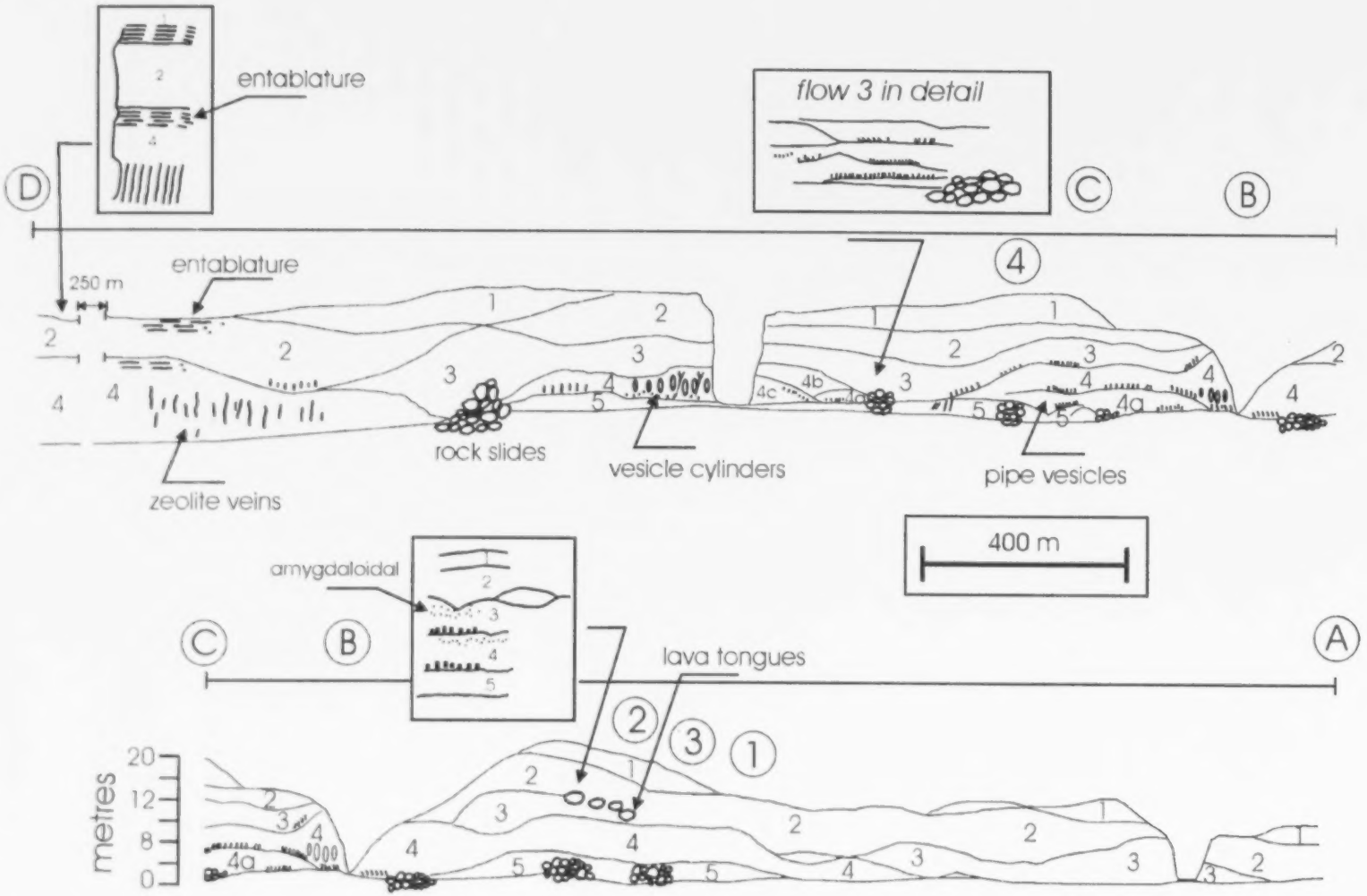

Figure 5. Long section parallel to the coastline from Margaretsville northeast towards Bishop Creek (between sections a and b in Figure 3) which shows flows of the middle flow unit of the North Mountain Basalt in the cliff section. Note that flow 5 outcrops extensively at low tide, but is not shown in the section. The section commenced northeast of Lighthouse Point past the wharf and a concrete retaining wall in front of a cottage. The section was generated by noting flow stratigraphy every 50-100 m along the traverse line parallel to the coastline. Note vertical exaggeration.

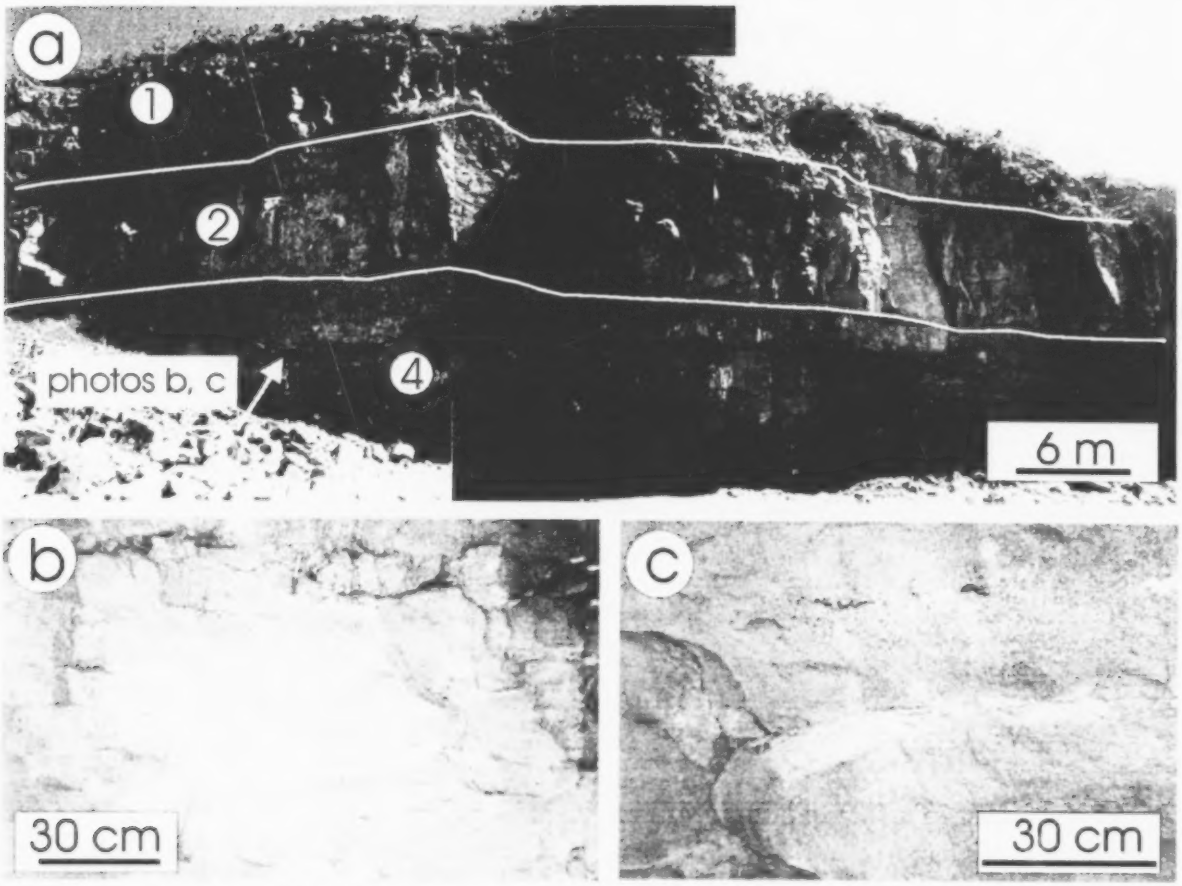

Figure 6. (a) Photo mosaic of MFU at point C, or station 18 along the section in Figure 5. Note the uniform thickness of flow 2 at this location. (b, c) Close up of flow 4 showing the presence of numerous, thin (i.e. 30-40 cm) flows.

(3) The amgydaloidal-rich nature of the MFU contrasts markedly with the massive and generally vesicle-free nature of the LFU and UFU. Is this feature a reflection of primary differences in melt chemistry (i.e. dissolved gas) or a consequence of different post-eruptive histories (i.e. rate of cooling, flow thickness, etc.)? If the former is correct, then it suggests multiple source magmas for the NMB.

(4) Why is the UFU absent from the north side of the Bay of Fundy? Is this a primary or erosional feature and what are the implications for both? As discussed above, it is suggested that this is a primary feature and may extend to the Scots Bay area where the Scots Bay Formation rests with slight discordance on zeolite-bearing basalts of the MFU. One obvious implication of this is that the feeder for the MFU would have to lie south of this area, which would be consistent with the apparent increase in its thickness towards East Ferry (Lollis, 1959; Fig. 2).

In order to address these problems additional field work is required, as well as integration of field studies with other techniques. For example, the extent of the MFU and UFU may be traced with the use of digital elevation model maps. The subtle changes in relief displayed in these images (Fig. 7) may relate to a change in nature of the basalt flows of the MFU, that is weathered versus fresh basalt as typifies, respectively, the red oxidized tops and more massive middle and lower parts. Similarly, it may be possible to trace out the contacts between the MFU, the LFU and UFU given the marked differences in the nature of the units. Following this work, it is hoped that a final map showing

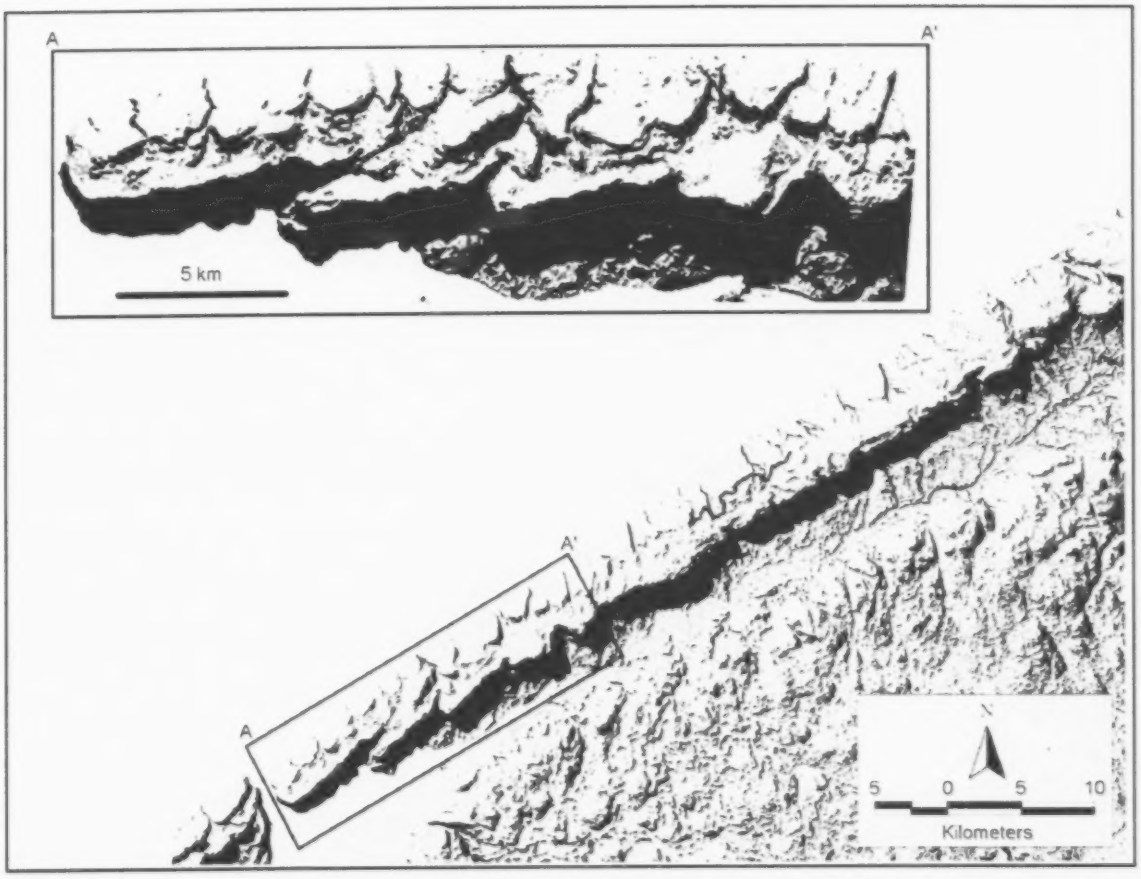

Figure 7. Digital elevation map with grey scale coloration of part of the Annapolis Valley region between Annapolis Royal and Digby. Note that the area northeast of Digby Gut has been enlarged to show detail. The North Mountain Basalt forms a prominent topographic feature that clearly indicates the extent of this unit. The enlarged area shows that the thick (i.e. ca. 150 m), lower flow unit is overlain by the middle flow unit and that multiple thin flows are recognizable and enhanced due to differential weathering of zeolitized flows.

distribution of the three units of the North Mountain Basalt, namely the LFU, MFU and UFU, can be produced which will have use in delineating favorable areas for occurrence of high-quality aggregate rock, zeolites, and metallic (Cu, Fe) minerals.

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Geoscience Editing and Publishing

D. R. MacDonald, B. L. MacDonald and J. S. Saunders

Publications play an important role in delivering geoscience information for the Minerals and Energy Branch, educating the public, and conveying the professional image established by the branch. A publication is often the first chance we have to make an impression on someone who comes into contact with the Department of Natural Resources.

Staff of the geoscience editing and publishing group work toward the goal of consistent high-quality, timely, and cost-effective reporting on activities carried out by the Minerals and Energy Branch. All geoscientists in the Branch are required to publish accounts of their work. These accounts may be published as scientific reports, memoirs or maps, or they may best be communicated in less technical publications such as information circulars or newsletters. The Branch newsletter *Nova Scotia Minerals Update* is produced quarterly and distributed to approximately 1600 subscribers around the world. The newsletter and many other publications are also converted to HyperText Markup Language (HTML) or Acrobat® PDF and are available on-line as part of the Minerals and Energy Branch web site. These activities ensure that current geoscience information on Nova Scotia is readily available to enhance public awareness and to promote the mineral resources of the province.

The role of the geoscience editing and publishing group in the Geoscience Information Services Section can be roughly divided into two parts. The first part involves editing a manuscript (report, article or map) to the author's satisfaction, while at the same time applying the branch standards for style and content in the interest of our readers. Editor Doug MacDonald carries out this work for the Minerals and Energy Branch. The second part involves producing a published document. The editor works with desktop publishing technicians Barb MacDonald and Susan Saunders to produce publications.

Editing

In the Minerals and Energy Branch, all scientific publications must be reviewed by at least one scientist who has not contributed to the research being presented. This process is called peer review and finding a suitable reviewer is usually the editor's first task after receiving a manuscript. The editor assigns the manuscript to a reviewer who is experienced in the field of study being presented by the author. The editor supplies the reviewer with detailed guidelines to direct the review toward the most critical scientific aspects of the manuscript. The reviewer's comments are then given to the author so that the manuscript can be revised in an effort to improve its scientific content. Open File Reports and Open File Maps are used to release information as soon as possible, and may be approved for publication after peer review, revision by the author and minimal editing.

Resubmission of the manuscript by the author after peer review initiates the next step in the editorial process, often called substantive editing. This step may require re-writing parts of the document, re-organizing sections, and generally suggesting ways that authors can improve the presentation of their research for the intended readers. The relationship between author and editor is most important during this phase of substantive editing.

Another aspect of the editorial process is often referred to as copy editing. This function requires careful attention to every detail in a document in order to meet the Branch publication standards. For the Minerals and Energy Branch, these standards reflect those used by the Geological Survey of Canada. Some standards, such as consistent capitalization, spelling and punctuation, are easily applied. Others may require much more time and effort, such as accurate citation and listing of references, and making sure that tables, maps and drawings meet the appropriate specifications.

Publishing

The final appearance of a publication is largely determined by the publication team, which includes an editor and a desktop publishing technician. This function consists of preparing camera-ready (or Internet-ready) manuscripts for publication, and

involves words, figures, tables and other design elements that are electronically composed using a variety of publishing applications, such as Word®, WordPerfect®, Publisher® and Acrobat®. Manuscripts travel back and forth between the editor and the desktop publishing technician many times before they are ready to be published, either on paper or on-line.

The following publications were released in 2001:

Contribution Series

CS ME 2001-1 Disseminated gold at Reefton, South Island, New Zealand, compared with similar occurrences in Victoria, Australia , and Nova Scotia, Canada, by A. B. Christie, N. G. Corner, F. P. Bierlein, P. K. Smith, R. J. Ryan and D. C. Arne; *in* New Zealand Mining, v. 28, p. 14-24.

CS ME 2001-2 Cretaceous Mafic dyke swarm, Peary Land, northernmost Greenland: geochronology and petrology, by D. J. Kontak, S. M. Jensen, J. Dostal, D. A. Archibald and T. K. Kyser; *in* Canadian Mineralogist, v. 39, p. 997-1020.

CS ME 2001-3 Late-glacial stratigraphy and history of the Gulf of St. Lawrence: discussion, by R. R. Stea; *in* Canadian Journal of Earth Sciences, v. 38, no. 3, p. 479-482.

CS ME 2001-4 Hidden Cretaceous basins in Nova Scotia, by R. R. Stea and S. E. Pullan; *in* Canadian Journal of Earth Sciences, v. 38, p. 1335-1354.

CS ME 2001-5 Glaciation and relative sea-level change in Maritime Canada, by R. R. Stea, G. B. J. Fader, D. B. Scott and P. Wu; *in* Geological Society of America, Special Paper 351, p. 35-49.

Economic Geology Series

EGS ME 2001-1 Overview of bedrock aggregate potential in the Halifax-Dartmouth metropolitan area, Nova Scotia, by G. Prime, 74 p.

Government of Nova Scotia Publication

Seizing the Opportunity, Nova Scotia's Energy Strategy; Government of Nova Scotia, 340 p.

Map

Map ME 2001-1 Geological map of the Meguma Group in the Rawdon area (part of NTS 11E/04), Hants County, Nova Scotia, by R. J. Horne, L. A. MacDonald and M. S. King, scale 1:50 000.

Newsletter

Nova Scotia Minerals Update, volume 18, numbers 1, 2, 3 and 4.

Open File Illustration

OFI ME 2000-1 Version 2 Active mining operations in Nova Scotia, by Mineral Development and Policy Section.

Open File Maps

OFM ME 2001-1 Map of bedrock aggregate potential in the Halifax - Dartmouth metropolitan area, Nova Scotia, by G. Prime, scale 1:100 000.

OFM ME 2001-2 Map of land use constraints in the Halifax - Dartmouth metropolitan area, Nova Scotia, by G. Prime, scale 1:100 000.

Open File Reports

OFR ME 2001-1 Fault-controlled zinc mineralization in the Antigonish Highlands, Antigonish and Pictou counties, Nova Scotia, by G. A. O'Reilly, 9 p.

OFR ME 2001-2 Geology of the South Mountain Batholith, southwestern Nova Scotia, by M. A. MacDonald, 359 p.

Reports

Report ME 2001-1 Minerals and Energy Branch Report of Activities 2000, ed. D. R. MacDonald, 179 p.

Report ME 2001-2 Mining Matters for Nova Scotia 2001: Opportunities for Economic Development, ed. D. R. MacDonald, 48 p.

Mineral Exploration Activity in Nova Scotia, 2001

P. D. McCulloch

Mineral Exploration Monitoring

Monitoring of mineral exploration activity in Nova Scotia is coordinated through the Registry of Mineral and Petroleum Titles of the Minerals Management Division by the author, who works out of the regional office in Stellarton, Pictou County. Regional Geologists of the Regional Services Branch offices in Coxheath (Don MacNeil), Truro (Donald Weir) and Bridgewater (Sandra Marshall) assist in field monitoring of mineral exploration activity in their respective regions.

The monitoring process covers exploration activities throughout the Province of Nova Scotia and consists of visits to company offices and exploration sites, liaison with industry personnel, and the review of current assessment reports and other material submitted by industry. Liaison with industry allows the department to maintain an awareness of current exploration activities. Assistance or advice is provided as necessary, and any drill core generated by mineral exploration activity is recorded as part of the monitoring process. This core may be recovered for archiving in the Drill Core Library in Stellarton when no longer required by the companies.

The Exploration Monitoring Geologist is also responsible for auditing confidential assessment reports that are submitted in support of the renewal of exploration licences. In 2001, 72 assessment reports were received and audited for compliance with the Mineral Resources Regulations.

Mineral Exploration Activity in 2001

In 2001, mineral exploration in Nova Scotia continued at approximately the same level of activity as in the previous two years. The level of field exploration expenditures has continued to decline over the past three years, however, with field expenditures expected to be in the range of $2.5-3 million for 2001, compared with $3-3.5 million in 2000 and $3.8 million in 1999 (Table 1, Fig. 1). Exploration focused primarily on industrial minerals and gold, with very little activity for base metals. In this regard, interest in the exploration and development of industrial mineral commodities has strengthened in recent years, whereas activities related to the exploration and development of base metals and gold continues to decline, due primarily to low commodity prices for metals and the difficulty in raising venture capital to fund exploration programs.

Preliminary figures for the total number of general claims staked in 2001 show a decrease of 26.9% from the previous year to 8000 claims (Table 1, Fig. 2). A preliminary total of 8220 claims for all commodities were in effect at the end of 2001, represented by 460 exploration, coal, tailings and special licences covering an area of 133 033 ha or 1 330 km^2, approximately 2.4% of the total area of the province. The amount of exploration drilling also decreased in 2001, with a preliminary estimate of 6 000 m compared with 8 500 m in 2000 and 13 300 m in 1999.

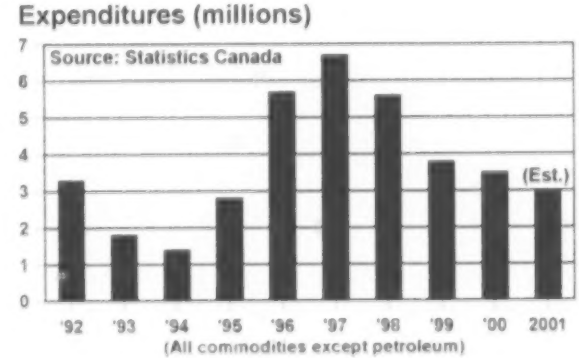

Figure 1. Exploration expenditures in Nova Scotia, 1992-2001.

Table 1. Details of exploration and development activity in Nova Scotia, 1992-2001.

	1992	1993	1994	1995	1996	1997	1998	1999	2000	F2001
Total Field Exploration Expenditures ($)	3 300 000	2 300 000	1 400 000	2 843 000	5 752 000	6 700 000	5 600 000	3 800 000	3 500 000	3 000 000
Total Licences Issued (all categories)	507	593	671	698	1 126	977	709	704	603	460
Claims In Good Standing (new and re-issued)										
General	11 157	9 504	13 740	15 861	33 399	25 190	11 452	14 045	10 951	8 000
Special (Order in Council)										
Salt and Potash	264	66	66	-	16	16	329	74	74	151
Coal	366	433	376	376	469	398	253	173	-	-
Tailings	94	146	146	146	146	146	-	-	-	-
Other	348	452	255	130	254	254	621	623	67	67
Uranium*	(226)	(226)	(226)	(226)	(226)	(226)	(226)	(226)	(226)	(226)
Total (excluding closures and uranium licences)	12 229	10 601	14 583	16 513	34 284	26 004	12 655	14 915	11 092	8 218
Total Area Held Under Licence (ha)	197 963	171 609	236 069	267 312	554 988	420 952	204 859	241 444	179 557	133 033
(acres)	489 160	424 040	583 320	660 520	1 371360	1 040 160	506 200	596 600	443 680	328 720
Work Reported for Licence Renewals ($)	2 333 972	983 402	1 694 368	1 601 639	2 376 023	3 146 899	5 385 194	2 969 047	1 136 304	2 811 393
Number of Assessment Reports Received	75	62	84	111	108	133	134	100	85	72

F Preliminary figures for 2001

* Parentheses around uranium claims indicate ground alienation due to the uranium moratorium

December 31, 2001

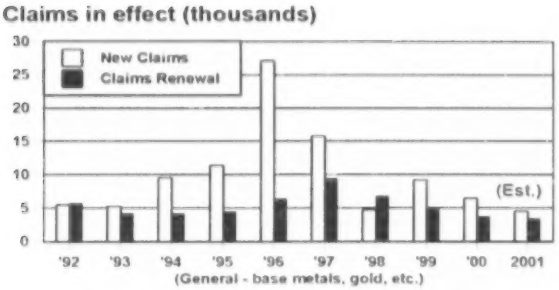

Figure 2. Claim staking in Nova Scotia, 1992-2001.

Approximately 214 companies and individuals held exploration interests (licences or options) in Nova Scotia in 2001, including 8 major, 10 junior and 48 private companies (Tables 2, 3 and 4). In addition, several mining lease holders carried out exploration on their leases or on unclaimed ground where these commodities did not require licences (e.g. limestone, gypsum). Organizations actively engaged in exploration during 2001 included 7 major, 4 junior and 6 private companies (Fig. 3, Table 5), as well as a number of individuals.

Exploration Activities

Industrial Minerals

Exploration and development work for industrial minerals was undertaken for several commodities, including kaolin, silica sand, zeolites, titanium, barite, salt and building stone. Work continued to focus on the development of kaolin silica sand, and quartz deposits, both in the central mainland area of the province and in the Flintstone Rock area in Yarmouth County. Work also continued to evaluate the zeolite potential of the North Mountain basalts along the southern margin of the Bay of Fundy, as well as the potential for commercial deposits of titanium-bearing sands along the Shubenacadie River in northern mainland Nova Scotia.

Black Bull Resources Incorporated, under an option agreement with CAG Enterprises Limited, continued a detailed exploration program for kaolin and silica in altered quartz-kaolinite breccia along the Tobeatic Shear Zone in the Flintstone Rock area, Yarmouth County. The company completed additional trenching and bulk sample testing on the property during the year and completed a preliminary evaluation of mica reserves associated with the kaolin and quartz. Black Bull has also initiated a product research program to investigate the development of value-added kaolin products for the paper and ceramics industries.

C_2C Zeolite Corporation continued a detailed evaluation of the zeolite potential of amygdaloidal basalts along North Mountain in western Nova Scotia. The company completed diamond-drilling and trenching on its Pelton Mountain Road property in Kings County and are continuing development work on the Tower View (Stronach Mountain) property. C_2C has been issued a mining lease on the Tower View property and has received conditional environmental approval for an open pit mining operation.

NAR Resources Limited and Titanium Corporation of Canada Limited amalgamated in July 2001 to form Titanium Corporation Inc. The company continued to evaluate the titanium potential of heavy mineral sands in the Shubenacadie River near Maitland, Hants County. The company completed additional drilling during the year and to date have delineated mineral sand reserves of 330.9 million tonnes grading 1.936% Ti-bearing heavy minerals.

Shaw Resources recently completed an overburden drilling program in the Admiral Rock - Shubenacadie area as part of an ongoing program to evaluate the potential for silica sand resources. The company currently operates a silica sand processing plant near Shubenacadie. Robert MacDonald and George MacKay continued a detailed evaluation of the former Novex Mining Pine Brook barite deposit at Lochside, Richmond County. Additional diamond-drilling was completed on the property early in the year.

Gold

Exploration for gold continued at approximately the same level of activity as in 2000. The lower Paleozoic Meguma Group of southern mainland Nova Scotia continued to be the principal focus for gold exploration in the province.

Table 2. Major companies involved in mineral exploration in Nova Scotia, 1999-2001.

	1999	2000	2001	Office location in 2001
Fundy Gypsum Company Limited	x	x	x	Windsor
Georgia Pacific Corporation	x	x	x	Sugar Camp
Lafarge Canada Incorporated	x	x	x	Brookfield
Little Narrows Gypsum Company Limited	x	x	x	Little Narrows
National Gypsum (Canada) Limited	x	x	x	Milford Station
Noranda Exploration Company Limited	-	-		
Pasminco Resources Canada Company (formerly Savage Resources Canada Limited)	x	x	x	
Statia Terminals Canada Limited	x	x	x	
W. M. C. International Limited	-	-	-	

x indicates work performed
- company inactive
blanks indicate that the company did not hold an exploration licence in that particular year

Newfoundland Goldbar Resources Incorporated completed surface diamond-drilling during the year to evaluate the strike extension of the gold-bearing saddle reef structures on the company's Dufferin Mine gold property at Port Dufferin. EnviroGold Technologies Incorporated, operators of the Dufferin Mine, began producing gold in May 2001 at a preliminary production rate of 200 tonnes/day.

True Metallic Explorations Incorporated continued an evaluation of the paleoplacer potential for gold associated with clastic sedimentary rocks of the Lower Carboniferous Horton Group near Castle Frederick, Hants County. The company completed an evaluation of a preliminary drilling program undertaken in the fall of 2000 and completed additional drilling on the property during the fall of 2001.

3779751 Canada Limited acquired the former Tangier Limited Partnership property at Tangier in mid-2000 to determine the potential for outlining mineable gold reserves in the vicinity of the former mining operations. The company completed a geological evaluation of previous exploration work on the property in 2000 and carried out a preliminary diamond-drilling program on the Strawberry Hill property along the eastern strike extension of the Tangier Anticline in 2001. The company also completed geological mapping and soil geochemical sampling on the western strike extension of the anticline during the year.

Strikezone Minerals (Canada) Limited, in an option agreement with Ellsin Resources Incorporated, continued an evaluation of the Lake Charlotte gold property, Halifax County. The company completed a soil geochemical survey on the property late in the year. Globex Mining Enterprises Incorporated initiated an exploration program during the year on the Mooseland gold property in Halifax County. Preliminary work consisted of a ground geophysical survey in the eastern area of the property.

A number of small exploration programs were also completed on several properties throughout the Meguma Group by individuals and private interests. Mr. Lindsay Allen completed additional work during the year on the Mill Village gold property in Queens County, including the de-watering and rehabilitation of the former Gold Eagle Mine shaft and preliminary underground

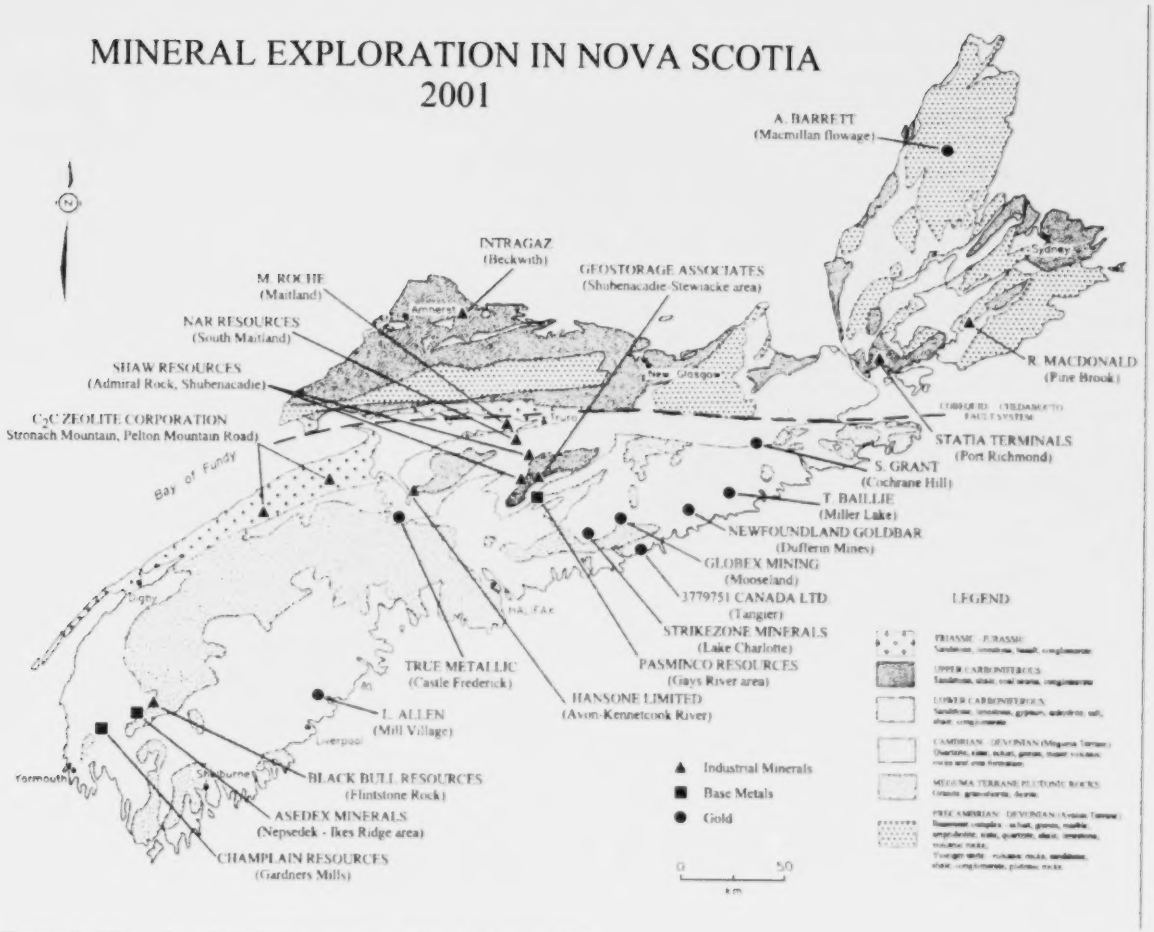

Figure 3. Mineral exploration programs in Nova Scotia, 2001.

sampling. Mr. Anthony Barrett continued to evaluate the MacMillan Flowage gold prospect in Victoria County, consisting of prospecting and bulk sampling of material excavated by Scotian Mineral Exploration Venture (Scominex) in 1987. Mr. Thomas Baillie completed additional work during the year on the Miller Lake gold property in Guysborough County, consisting of detailed prospecting. Mr. Scott Grant initiated a detailed rock sampling program in the open pit area of the former Northumberland Mines property at Cochrane Hill, Guysborough County.

Base Metals

Exploration for base metals in 2001 continued at approximately the same level of activity as in 2000, and focused primarily on areas of known mineral occurrences in the northern and western areas of mainland Nova Scotia.

Pasminco Resources Canada Company began a preliminary evaluation of the Pb-Zn potential of several areas underlain by Lower Carboniferous Windsor Group carbonates in the general vicinity of the company's Gays River Pb-Zn deposit in 2000. The company completed additional geochemical surveys in the area during 2001.

Asedex Minerals Corporation Limited initiated an exploration program for tantalum and associated base metals in the Nepsedek and Ikes Ridge areas south of East Kemptville, Yarmouth County, during 2001. Preliminary work included extensive prospecting and rock sampling. Champlain Resources Incorporated also carried

Table 3. Junior exploration companies in Nova Scotia, 1999-2001.

	1999	2000	2001	Office location in 2001
Black Bull Resources Incorporated	x	x	x	
C-C Zeolite Corporation	x	x	x	Kentville
Corner Bay Minerals Incorporated	-	-	-	Cold Brook Station
Exploration Orex Incorporated	-	-	-	
Globex Mining Enterprises Incorporated	-	-	-	
Heartland Resources Limited	-	-	-	Dartmouth
NAR Resources Limited	x	x	x	
Regal Goldfields Limited	-	-	-	
Roycefield Resources Limited	-	-		
RJZ Mining Incorporated	x	-	-	
Titanium Corporation of Canada Limited	x	x	x	

x indicates work performed
- inactive
blanks indicate that the company did not hold an exploration licence in that particular year

out preliminary prospecting and geological mapping to evaluate the tantalum potential in the Gardners Mills area, Yarmouth County.

Other

Statia Terminals Canada Limited continued an evaluation of the potential for developing underground bulk hydrocarbon storage in the extensive salt deposits of the Lower Carboniferous Windsor Group in the Port Richmond area near Port Hawkesbury. Recent work included a review of previous geological and geophysical work completed on the property.

Geostorage Associates continued to evaluate the potential for developing under-ground bulk storage of hydrocarbons in the Lower Windsor salt deposits underlying the Shubenacadie-Stewiacke area of central mainland Nova Scotia. Recent work has focused on a review of previous drilling and geophysical work completed in the area. Intragaz and Company Limited Partnership also continued an evaluation of the Lower Windsor salt deposits of the Cumberland Basin for potential hydrocarbon storage in the Beckwith area in northern mainland Nova Scotia. Recent activities have focused on a review of previous geological and geophysical work completed in the area.

Table 4. Private exploration companies in Nova Scotia, 1999-2001.

	1999	2000	2001	Office location in 2001
166881 Canada Incorporated		-	-	
3779751 Canada Incorporated		-	-	
Atlantic Industrial Minerals Limited	-	-	-	
Asedex Minerals Corporation Limited	-	-	-	
Aurion Minerals Limited	-	-	-	
Broad River Exploration	-	-		
Burnt Point Resources Incorporated	X	-	-	Halifax
C.A.G. Enterprises Limited	X	X	X	Antigonish
Cannova Goldfields Incorporated	X	-	-	
Cape Minerals Limited	-	-	-	
Champlain Resources Incorporated	-	-	-	
Cobequid Life Sciences Limited	-	-	-	
Conrad Brothers Limited	-	-	-	Dartmouth
D&D Metal Detectors Limited	-	-		
D. R. Duncan & Associates Limited	-	-		
Datum Quest Explorations	X	-		
Dufferin Resources Incorporated	X	X	X	Halifax
Earth Search Sciences, Incorporated		-	-	
Ellsin Resources Incorporated	X	X	X	
Elmsdale Landscaping Limited			-	
Emerald Isle Resources Incorporated			-	
Gallant Aggregated Limited	-	-	-	
Gammon Lake Resources Incorporated	-	-	-	Halifax
Geocol Mining & Exploration	-	-		
Geosearch	X	X	-	Sackville
Giant Meguma Holdings	-	-		Halifax
Glencoe Resources Incorporated		X	-	
Gold 'n' Crystal Minerals	X	X	-	East Advocate
Golden Ace Mineral Explorations Limited	X	X	-	
Goliath Copperfields Limited	-	X	-	
H & E Mullen Investments Limited	-	X	-	
Hansone Limited	X	X	-	
Hibernia Minerals Incorporated	-	-		
Highland Range Minerals Limited	-	-	-	
Huntington Explorations Incorporated	-	-	-	
Intragaz & Company Limited Partnership	-	-	X	
John Logan Enterprises Limited	-	-	-	
Jubilee Minerals	X	-	-	Bedford
KaoClay Incorporated	X	X	-	Milford Station
Kelly Investments Limited	-	-	-	
Kelly Rock Limited	X	-		Sydney
Little Lake Gold Mines Limited	-	-		Dartmouth
Lynx Minerals Corporation	X	X	-	
MacLeod Resources Limited			-	
Maritime Mica Incorporated	-	-	-	
Mercator Geological Services Limited	X	-		Dartmouth

Table 4. Continued.

	1999	2000	2001	Office location in 2001
Minas Basin Pulp & Paper Company Limited	-	-	-	
Mineral City Enterprises Incorporated		-	-	
Mount Cameron Minerals Incorporated	x	-	-	
North Cape Breton Resources Limited	x	-	-	
Nycon Resources Incorporated			-	
Oceanview Minerals Limited			-	
Ochter Holdings Limited	-	-		
Pan East Petroleum Corporation (formerly Pan East Resources Incorporated)	-	-	-	
Prodigy Resources Incorporated	-	-	-	
Rainbow Resources Limited	-	-	-	Dartmouth
Remoscan Limited	x	-		
Robert Stewart-Patterson & Associates			-	
The Shaw Group Limited (formerly L. E. Shaw Limited)	x	x	x	Lantz
Tangier Limited Partnership (formerly Tangier Mining Incorporated)	-	-		
Tri-Explorations Limited	-			
True Metallic Explorations	x	x	x	Bedford
Uravan Minerals Incorporated	-	-		
Votix Corporation Limited	x	x	-	Trenton

x indicates work performed
- inactive
blanks indicate that the company did not hold an exploration licence in that particular year

Table 5. Mineral exploration programs in Nova Scotia, 2001.

COMPANY/INDIVIDUAL	LOCATION	COMMODITY	PROGRAM
3779751 Canada Limited	Tangier, Halifax County	Gold	Diamond-drilling, geochemical sampling
A. Barrett	MacMillan Flowage, Victoria County	Gold	Prospecting, bulk sampling
Asedex Minerals Corporation Limited	East Kemptville area, Yarmouth County	Tantalum	Prospecting, rock sampling
Black Bull Resources Incorporated	Flintstone Rock, Yarmouth County	Kaolin, silica sand	Trenching, bulk sampling
C_2C Mining Corporation	Stronach Mountain, Annapolis County	Zeolites	Preliminary development work
	Pelton Mountain, Kings County	Zeolites	Diamond-drilling, trenching
Champlain Resources Incorporated	Gardners Mills, Yarmouth County	Tantalum	Prospecting, geological mapping
Geostorage Associates	Shubenacadie area, Colchester County	Salt (underground storage)	Review of previous work
Globex Mining Enterprises Incorporated	Mooseland, Halifax County	Gold	Ground geophysics
Intragaz and Co. Limited Partnership	Beckwith area, Cumberland County	Salt (underground storage)	Review of previous work
L. Allen	Mill Village, Queens County	Gold	Shaft rehabilitation, rock sampling
NAR Resources Limited	Shubenacadie River, Hants County	Mineral sands	Drilling, geochemical sampling
Newfoundland Goldbar Resources	Dufferin Mines, Halifax County	Gold	Underground development work, diamond-drilling
R. MacDonald/G. MacKay	Lochside, Richmond County	Barite	Diamond-drilling
Pasminco Resources Canada Company	Gays River area, Halifax County	Base metals	Geochemical sampling
S. Grant	Cochrane Hill, Guysborough County	Gold	Rock sampling
Shaw Resources	Admiral Rock, Hants County	Limestone	Diamond-drilling
	Shubenacadie, Hants County	Limestone	Diamond-drilling
Statia Terminals Canada Limited	Port Richmond, Richmond County	Salt (underground storage)	Review of previous work
Strikezone Minerals (Canada) Limited	Lake Charlotte, Halifax County	Gold	Geochemical sampling
T. Baillie	Miller Lake	Gold	Prospecting
True Metallic Explorations Inc.	Upper Falmouth, Hants County	Gold	Diamond-drilling

Investigation of Polished Sections and Analysis of Digital Elevation Model (DEM) Data from Rare Element Pegmatites at Lower Caledonia (NTS 11E/08) and Seffernsville (NTS 21A/09), Nova Scotia

R. F. Mills

Introduction

Recent recognition of potentially ore-grade beryllium, and evaluation of further occurrences of important elements such as Ta, Nb, Cs and Rb at Lower Caledonia, Guysborough County, have renewed interest in pegmatite occurrences in Nova Scotia. Pegmatite occurrences at Lower Caledonia and Seffernsville, Lunenburg County (Fig. 1), were recently the subjects of Prospector Assistance projects. The Prospector Assistance Program (1998 to 2000) provided seed funding to Nova Scotia prospectors as part of a federal - provincial cooperation agreement that required input from local prospectors as well. These and other exploration targets are receiving new, due consideration for the presence of elements that are in great demand today owing to the development of new technologies. Beryllium is used in the manufacture of ultra light and strong alloys, such as those used for fighter jet airframes, tantallum in computer chip materials and high temperature ceramics, cesium in the manufacture of new chemicals and rubidium in medical research. The market prices for these elements, while volatile, make them valuable commodities in relation to other metals.

Lower Caledonia Pegmatite

The pegmatite that hosts the Lower Caledonia beryllium occurrence was documented, and even diamond drilled, by more than one investigator (Armstrong, 1969; McMullin, 1976) as part of the evaluation of an adjacent gold - base metals exploration target. A shaft was also sunk within 50 m of one of the key outcrops described in the beryllium discovery (Goudge, 1937; Fig. 2). None of these workers recognized the presence of beryl, presumably because to beryl is easily mistaken for feldspar.

During the 1999 field season the site was visited by Nova Scotia Department of Natural Resources geologist G. A. O'Reilly, who was checking the gold - base metals prospect known as the McLaren workings. He recognized beryl in the pegmatite and presented the information to the public and industry at the Nova Scotia Department of Natural Resources Open House and Review of Activities in 1999. As a result, the prospect was staked.

History

The following history is summarized from O'Reilly, 1999. The first well documented report of work in the Lower Caledonia area was done by Goudge (1937), who described the 5 m deep shaft, trenches and related work done on the quartz veins of the McLaren workings. One of these veins returned levels in excess of 3/4 oz. Au per ton. Also noted with the free gold were pyrite, chalcopyrite, galena and sphalerite. This subsequently led to the prospect receiving attention as a base metals target as well as a gold prospect, and the site was drilled in the 1960s by two companies (Meagher, 1966; Armstrong, 1969), as well as a third in the 1970s (McMullin, 1976). The pegmatite, in which beryl was subsequently recognized, was intersected by this drilling, according to drill core records. The drillholes also encountered anomalous Zn (up to 0.33%), Pb (up to 0.15%) and Ba (0.07%). Tellurium was reported as well, but has never been confirmed at the occurrence.

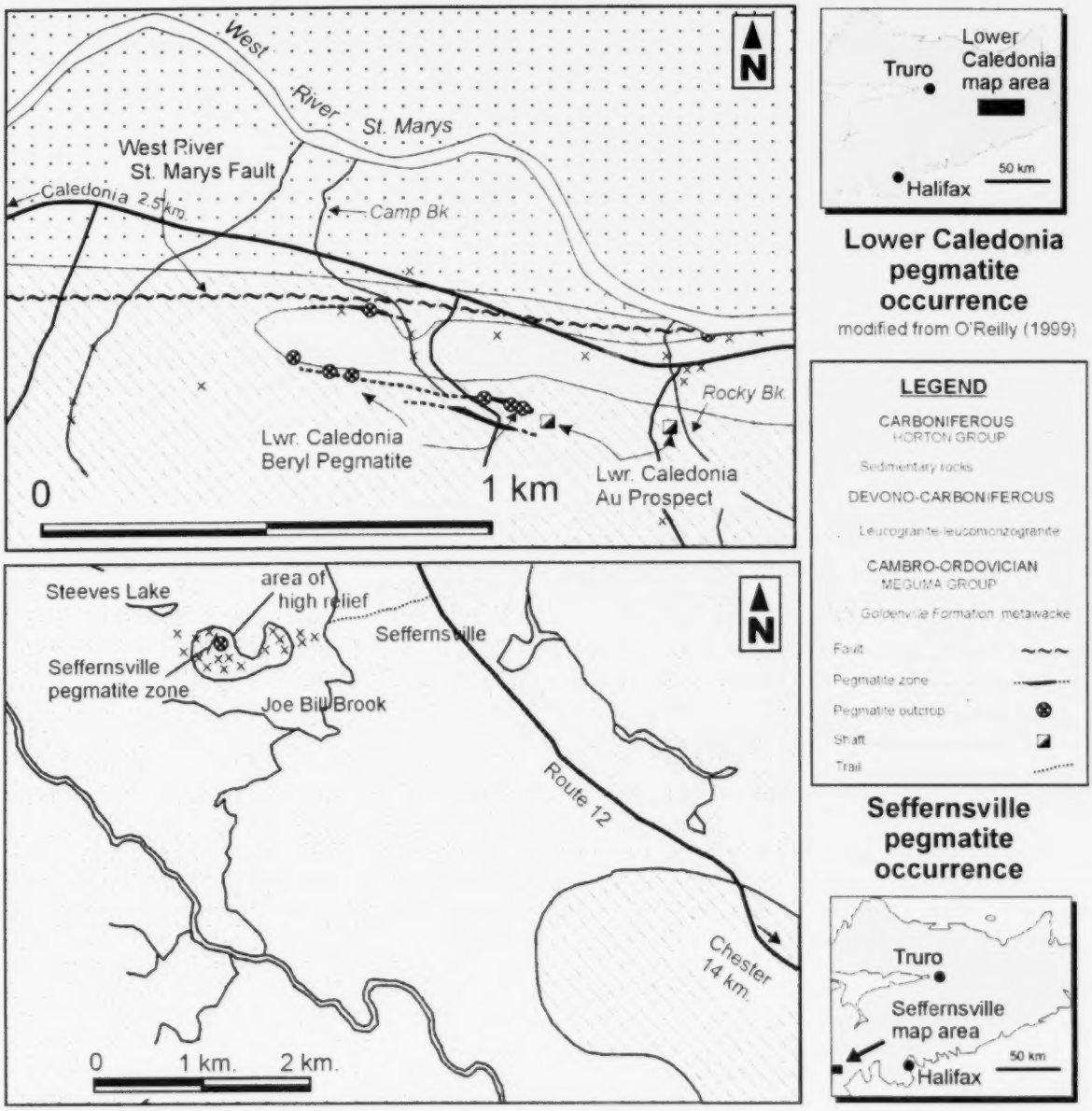

Figure 1. Geological maps of the Lower Caledonia and Seffernsville areas, showing locations of the pegmatite occurrences.

Description of Outcrops

Outcrops were examined in the 2000 and 2001 field seasons and occur west of the bush road running south and uphill from the Caledonia - Lower Caledonia highway, and approximately 300 to 400 m west of the outcrops described by O'Reilly (1999). Overburden cover in the area is extensive and the actual width of the pegmatites is not known. It is also not known if these outcrops represent a single pegmatite, or are separate parts of a pegmatitic swarm underlying that area. The pegmatites are roughly on strike with those described by O'Reilly (1999). The first (eastern-most) and second (middle) outcrops are very close

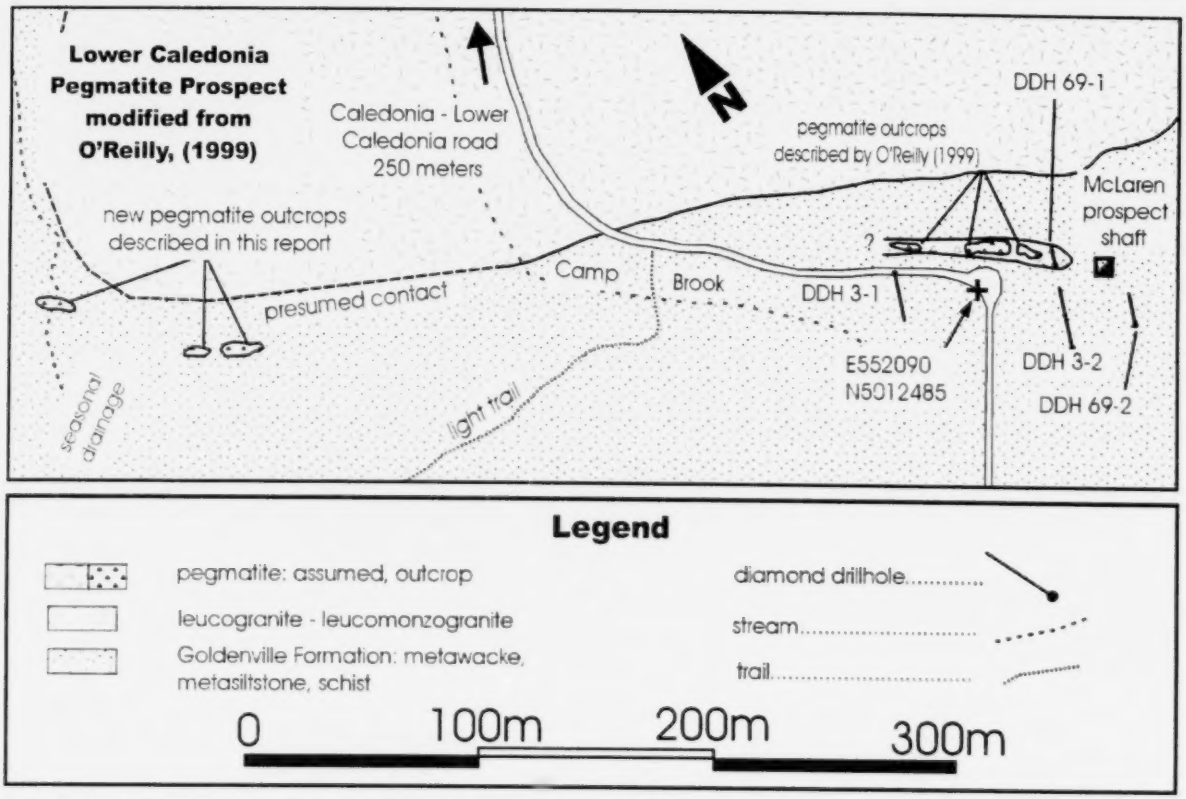

Figure 2. Geological map of the Lower Caledonia pegmatite occurrence.

to one another and are probably connected; however, the third (westernmost) outcrop is not on the same strike as the first two. This may represent a separate pegmatite from the first two outcrops, or the same pegmatite curved toward the north, around, and close to the edge of a small leucogranitic body (Fig. 2).

Comparing these three outcrops with those described by O'Reilly (1999), it is notable that the groundmass of the new outcrops seems to be marginally to significantly more coarse than the exposure to the east described by O'Reilly (1999).

The First (Easternmost) Outcrop

The first outcrop was found along a bush road approximately 275 m west to the west of O'Reilly's (1999) outcrop. To reach this outcrop, follow the trail southwest for 60 m, then west for approximately 75 m before turning due north off the trail and walking for about 50 m. The exposure measures approximately 3 m long (east to west) and 1.5 to 2 m wide and was found at (NAD 20) UTM coordinates E551764, N5012621. The outcrop consists of large blocks (0.2 m to 0.75 m) of pegmatitic colluvium that are broken and misplaced slightly but, basically *in situ*. The outcrop is partially obscured by moss and other vegetation. It is hard to comment on many of the features of the pegmatite at this location, such as zoning, due to the poor nature of the outcrop. However, some general observations reveal that these blocks are noticeably more megacrystic than the outcrops described by O'Reilly, approximately 275 m to the east. The colluvium displays much of the mineralization noted by O'Reilly in the outcrops proximal to the McLaren prospect. Minerals include abundant megacrystic potassium feldspar, tourmaline, and beryl, which was noted in at least one large angular block from this location. Large 3-4 cm crystals of a buff, unidentified (possibly feldspar) mineral are also present.

The Second (Middle) Outcrop

The second outcrop measures approximately 6 m long (east to west) and 2.5 m wide, and was found at UTM coordinates E551744, N5012633, which is approximately 20 m farther west along strike of the pegmatitic body. This outcrop consists of large blocks of pegmatitic colluvium from 0.2 m to 0.75 m in size lying around and over pegmatitic outcrop. Partially obscured by vegetation, the exposure is somewhat poor, but zoning is notable in this outcrop. Quartz is displayed as well as abundant tourmaline in close association to thin (2-6 cm) bands of schistose country rock. The texture is as coarse as the first (easternmost) outcrop, but displays a planar fabric parallel to the strike of the dyke (approximately 325°). The outcrop consists of massive megacrystic plagioclaise feldspar, quartz, and a few large (1.5-3.0 cm) crystals of beryl.

The Third (Westernmost) Outcrop

Approximately 65 m west of the second outcrop is a small, seasonal stream. Follow this north (downstream), for approximately 40-60 m to a pegmatitic exposure below a small waterfall in a stream cut. The pegmatite measures approximately 5 m long (east to west) and 2.5 to 3 m wide, and is exposed on both sides of the stream. The dyke appears to continue at both ends where it is obscured.

There is less quartz at this location, but both tourmaline and beryl are more abundant than in the previously described outcrops. There are other black opaque minerals present that may or may not be tourmaline. Small-scale zoning can be seen in the outcrop, but an overall fabric is not apparent. Beryl crystals are relatively large, up to 2.5 cm. Several quartz veins and stringers cut the exposure.

The outcrop lies on the eastern side of a pronounced, 40 m wide ridge that runs north-south. Tourmaline-rich pegmatite can be seen on the western side of the ridge as well, due west of the third outcrop, in angular pegmatitic colluvium. At this time it is unknown whether the ridge itself represents a pegmatitic body oriented north - south, or if the pegmatite in the stream is oriented east-west.

Seffernsville Pegmatite

The Seffernsville pegmatite is located in an outcrop on a very high granite knob at UTM coordinates E387089, N4945375, approximately 3.5 km west of the village of Seffernsville, Lunenburg County (Fig. 3). The exposure is difficult to find by Nova Scotian standards. It is accessed via a bush road running west from Seffernsville off Route 12, to the junction with Joe Bill Brook. At this point, one must walk to the site following a foot path until the trail becomes obscured with overgrowth, then shooting a line with an orienteering compass on an azimuth of roughly 225° (south-southwest). The surrounding area is covered with thick boreal forest. A G.P.S. is recommended to help find the site. The hill hosting the site rises far over the surrounding terrain. Once close to the locality one can find the occurrence by locating and climbing the highest local hill.

Leading up to the site, west of Joe Bill Brook, there are exposures of unmapped Goldenville Formation rocks west of the stream. The granitic knob that hosts the pegmatite consists of coarse-grained, two-mica monzogranite and rises at least 15 m over all surrounding terrain. The site is marked by two trenches dug under the auspices of Faribault (1924), on the north side of the hill, approximately 100 m from the crest.

History

The Seffernsville pegmatite occurrence was first located and trenched by Faribault (1924). Ellsworth (1932) describes the site as having, "...the finest examples of smokey quartz crystals so far found in Canada, both in regard to perfection of form and depth of coloration...". Lepidolite is also reported to have been identified at the site by Ellsworth. No exploration of any significance has been done at the occurrence since Faribault's pits were excavated, though rocks in the area were explored on a more regional level in the 1970s and 1980s for granophile elements such as Sn, W, Mo, radioactive elements, and gold in the surrounding Meguma Group as part of a regional exploration program.

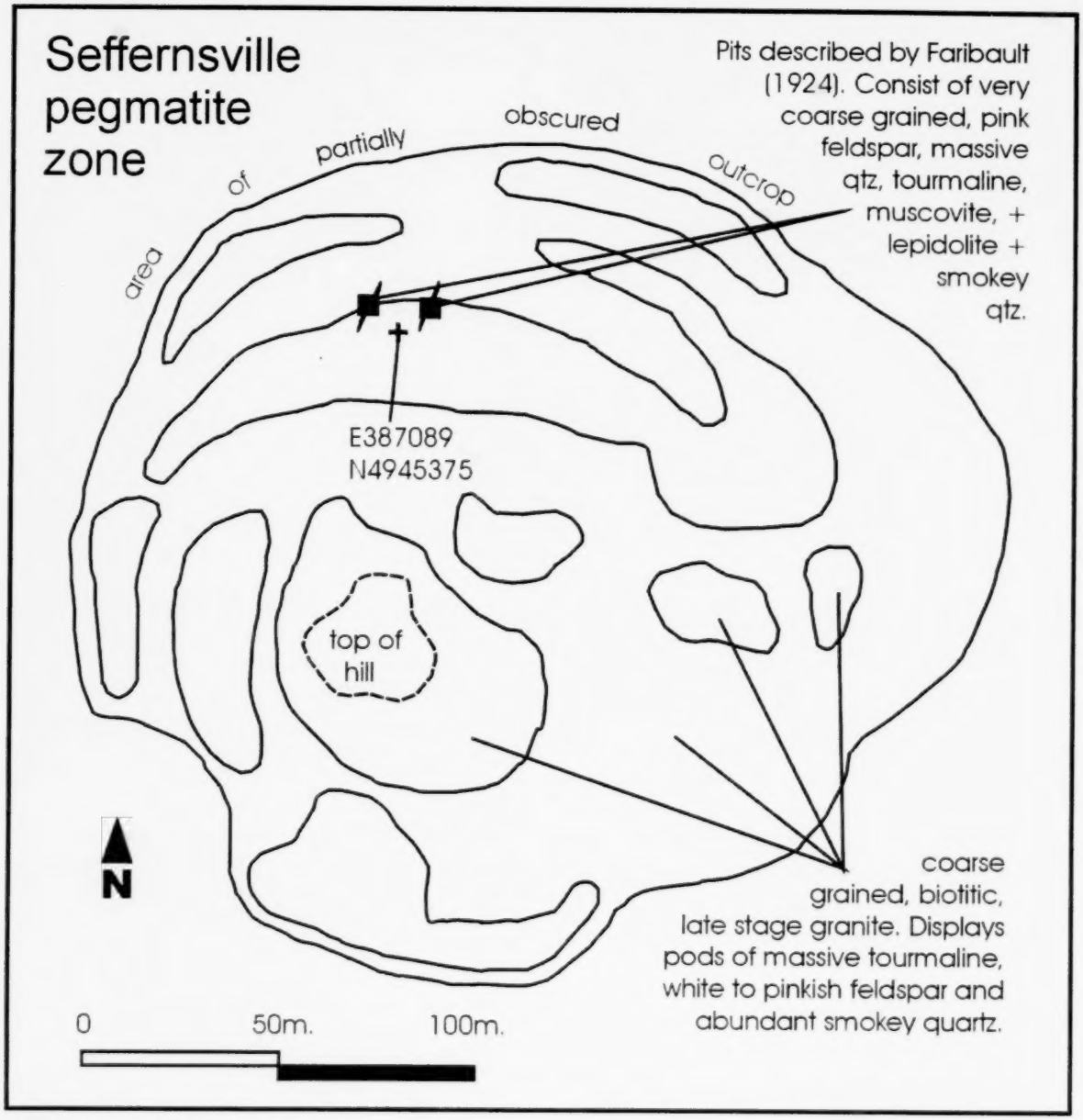

Figure 3. Sketch of the Seffernsville pegmatite zone.

Description of the Seffernsville Outcrops

The high knob-like granitic host for the occurrence consists of coarse-grained, two-mica monzogranite, cut by stockworks of quartz and smaller pegmatitic dykes. Under stereoscopic analysis, air photos reveal the high knob is surrounded by a series of partially circular ridges that are interpreted to represent some phase of convection or a separate magma pulse within the local intrusion. The pegmatite strikes approximately 010° at the occurrence and has been trenched by two pits approximately 20 m apart. The easternmost pit is marked on the east side by approximately 0.5 m of massive, coarse, megacrystic potassic feldspar, exhibiting tourmaline, large muscovite crystals and

abundant smokey quartz. The west side of the pit displays massive white quartz up to 2.5 m wide. West of this pit the exposure is partially obscured with lichen and moss, but the massive nature of the quartz and coarse pegmatite is evident in the outcrop between the pits. The westernmost pit is also marked by abundant quartz development and massive, coarse potassium feldspar. Minor lepidolite was noted in dump samples from this pit. Lepidolite crystals were surrounded by a zone of feldspar in one instance. Minor iron sulphides, abundant muscovite, and tourmaline were also noted. There are several other unidentified dark, opaque minerals present in minor or trace amounts. Fluorite is also reported to have been recovered from the site (B. Paul, personal communication).

Analytical Methodology

Hand specimens were collected and inspected visually with a binocular microscope. Polished sections were made from samples recovered from the newly described Lower Caledonia pegmatite outcrops and the Seffernsville pegmatite occurrence. The sections were investigated by electron microprobe at Dalhousie University, Halifax, Nova Scotia. Backscatter images were also recorded (Fig. 4).

As part of the spatial analysis to the parental intrusives, three-dimensional wireframe images (maps) and shaded relief images (maps) were produced using recently released digital elevation model (DEM) data from the Geological Survey of Canada (1999; Fig. 5).

Results

Hand Specimens

At Lower Caledonia, beryl was identified in the field, as well as galena. Lepidolite was positively identified in the field at Seffernsville. Trace sphalerite was also noted at Seffernsville.

Polished Sections, Lower Caledonia

The slides revealed an overall groundmass in the Lower Caledonia pegmatite that was very different from the Seffernsville samples. (Fig. 4). The groundmass of the Lower Caledonia pegmatite exhibits three distinct phases of feldspar development. These phases are relatively uniform in nature, and produce a massive, amorphous groundmass that appeared to cool uniformly. Anomalous levels of Zr (42.9%), Nb (5.7%), Cs (0.091%) and Ba (0.97%) were noted. The unidentified buff mineral seen in the field at Lower Caledonia contains SiO_2 (67-68%) and Al_2O_3 (19-20%), with approximately 80% of the probe beam returned. Unfortunately, microprobe analysis is not sufficient for analysis of several of the lighter elements under investigation at the Lower Caledonia site, such as Be. A lack of suitable analytical standards gave inconclusive analyses for Ta and Cs.

Polished Sections, Seffernsville

Samples produced from Seffernsville revealed a groundmass of different appearance from that recorded at Lower Caledonia. The crystal texture shows a brecciated (cataclastic) fabric in the groundmass of the pegmatite. There is a mineral phase present that fills the interstitial space and cuts across other crystals (albite, quartz) in the groundmass. Microprobe analysis is not sufficient for analysis of the same elements under investigation at the Seffernsville occurrence site, such as Be and Li, and produced inconclusive results.

Digital Elevation Model (DEM) Analyses

Data reduction of the Caledonia area DEM reveals ridges representing the small parental intrusive, as well as several other local ridges that may represent further pegmatites in the area. Approximately 750 m west-northwest, a similar topographic feature to the parental granitic body is clearly exposed in the DEM wireframe diagram (Fig. 5a.).

The Seffernsville DEM displays the high topographical feature that hosts the known pegmatite in the area, as well as the outline of the leucocratic intrusive parent. There are many small ridges around the site that could represent pegmatites; an

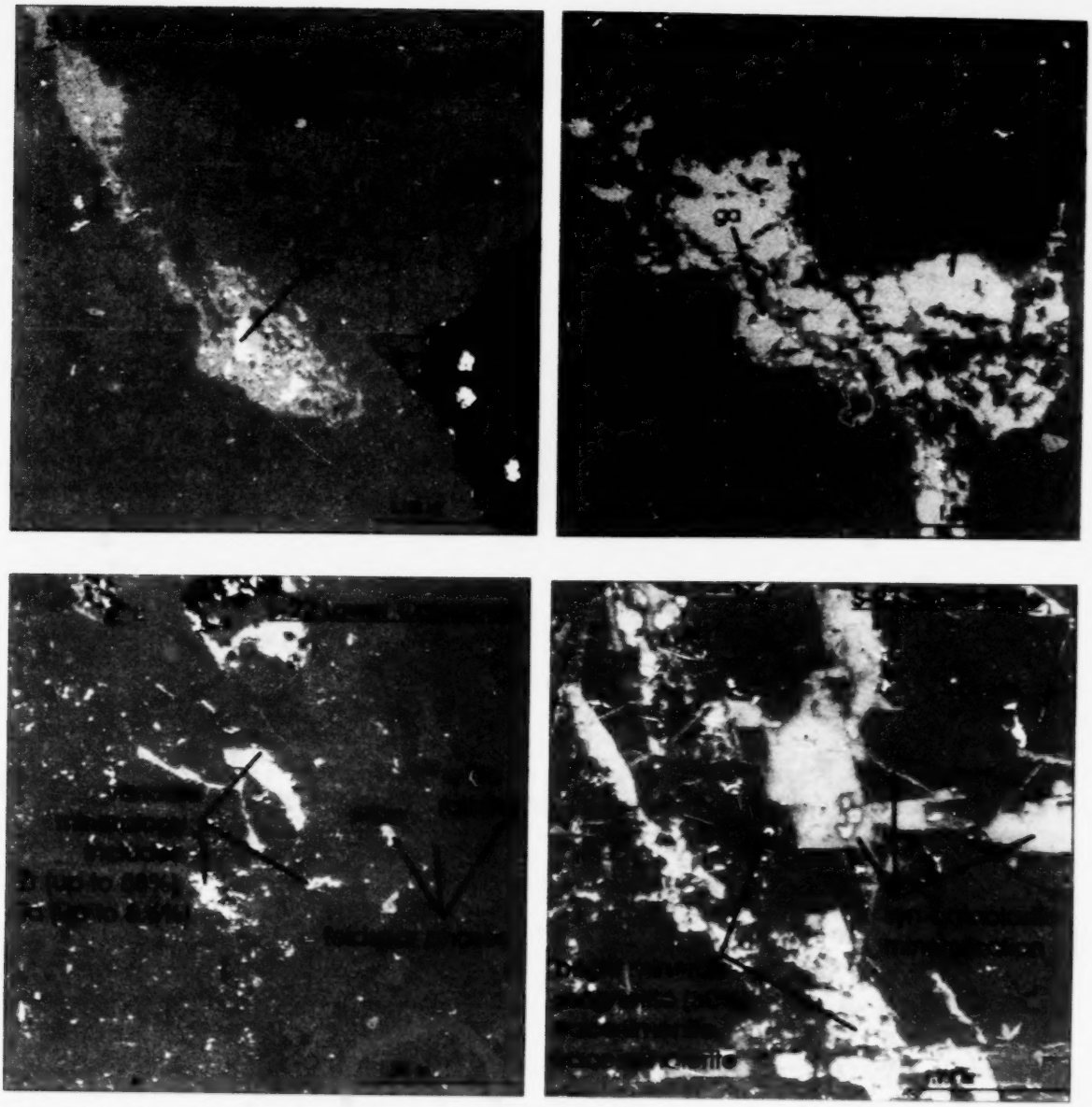

Figure 4. Scanning electron backscatter images from Lower Caledonia (both upper images and lower left) and Seffernsville (lower right). Phased groundmass mineralization at Lower Caledonia appears syngenetic and presumably relates to primary cooling. Groundmass mineralization at Seffernsville follows a cataclastic fabric. This phase is believed to represent genetic alteration or partial anatexis of an existing fabric.

S-14 Lower Caledonia
albite phase with minor
tantalite (4%)

S-17 Lower Caledonia
feldspar
groundmass
phase
minor tantalum
(4.7%) in albite

S-22 Lower Caledonia
variable
mineralogy
includes
Zr (up to 58%),
Ta (up to 6.6%)
>Co
>Na
(albite)
Accessory phases

S-23 Seffernsville
syn-cataclastic
mineralization
bright minerals
magnetite (30%),
trace ilmenite,
trace sphalerite

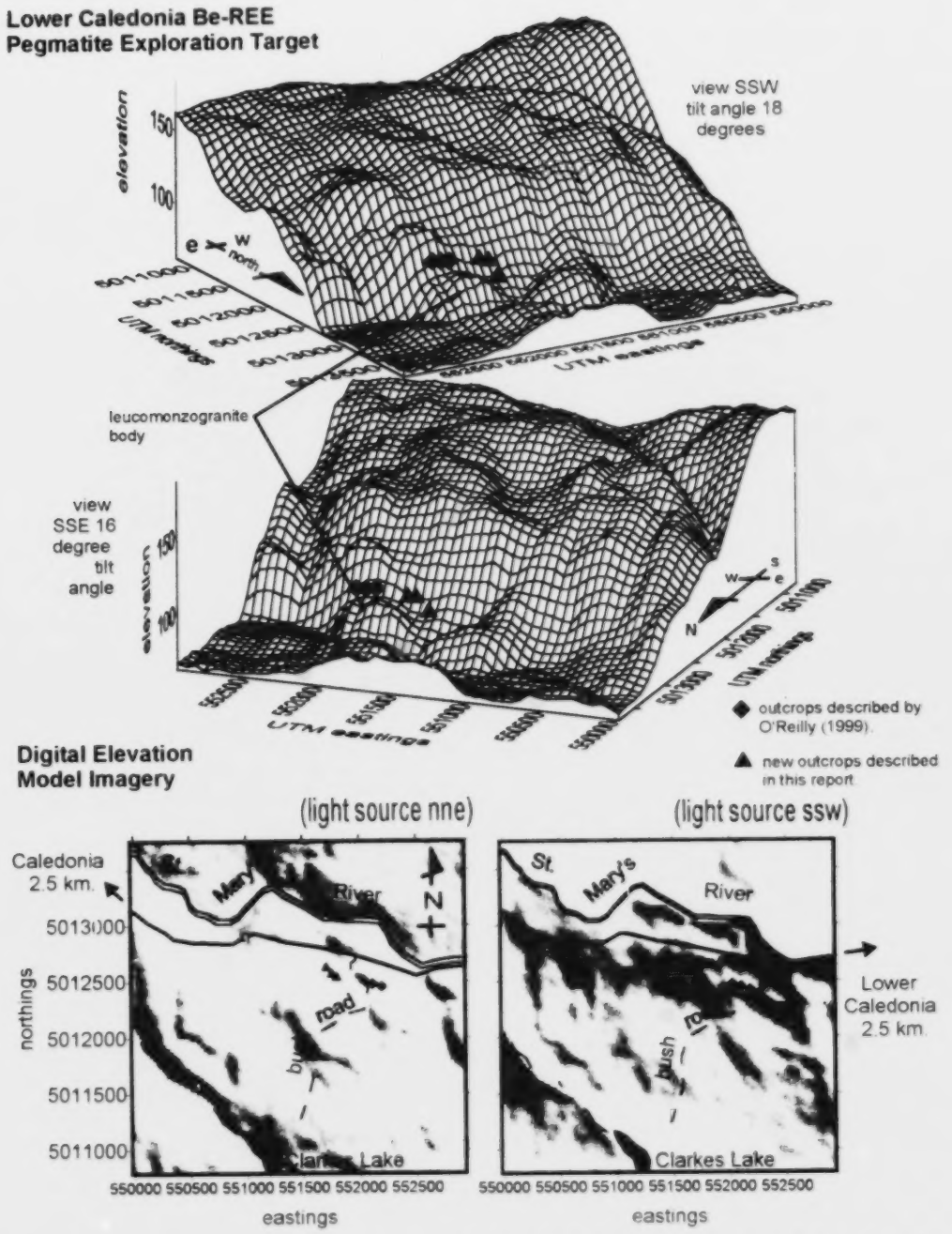

Figure 5a. Three-dimensional wire frame images and shaded relief images of the Lower Caledonia pegmatite occurrence, based on digital elevation model data (Geological Survey of Canada, 1999).

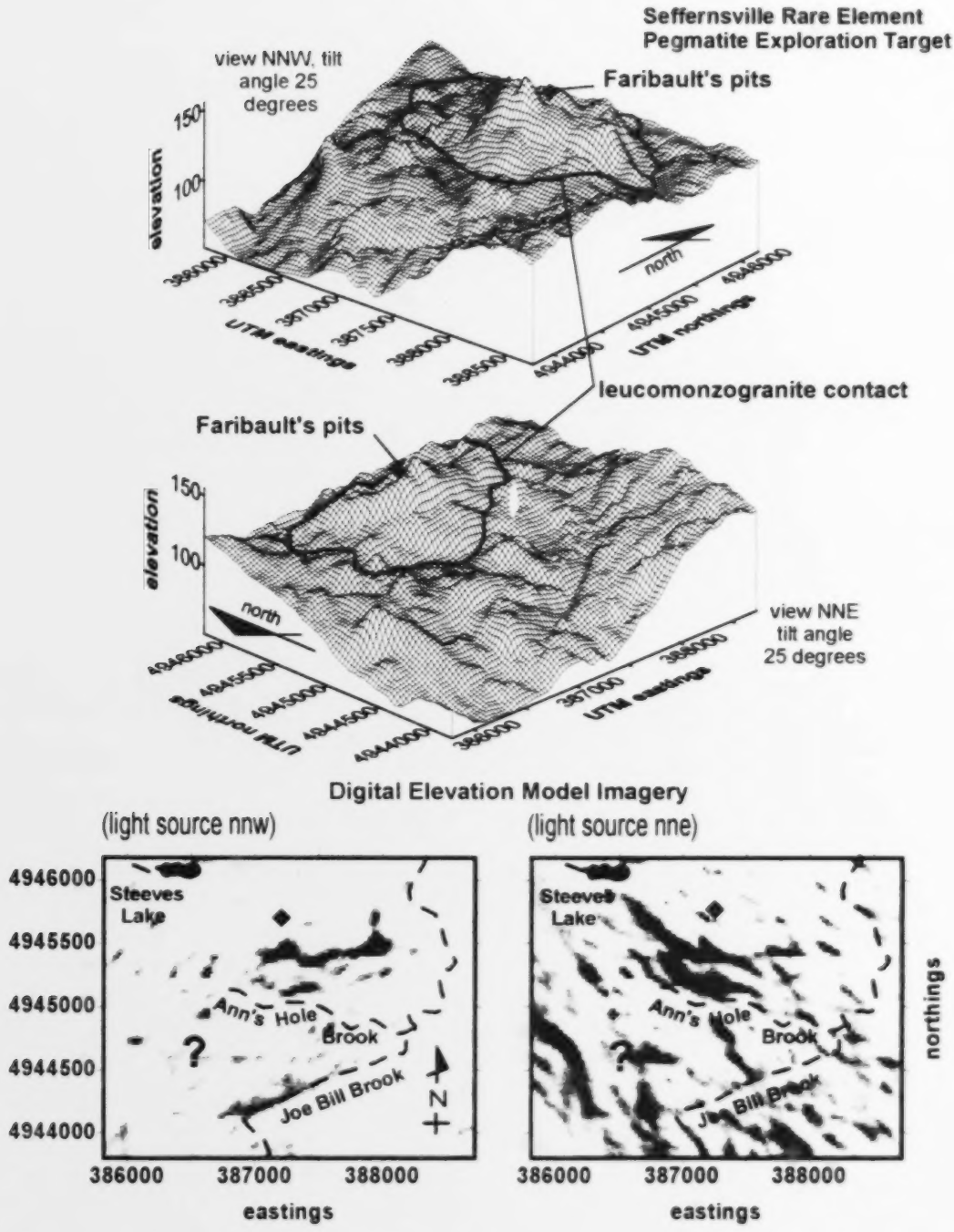

Figure 5b. Three-dimensional wire frame images and shaded relief images of the Seffernsville pegmatite occurrence, based on digital elevation model data (Geological Survey of Canada, 1999).

area 1200 m south - southwest of the occurrence is a notable example (Fig. 5b.). This area displays a strong magnetic signature similar to that for the known pegmatite (King, 1997).

Discussion

Lower Caledonia

Pegmatite outcrops were known to exist north of the small leucocratic intrusion, as well as to the south (King, 2001). It is possible that several pegmatites were intruded, roughly stratabound with east-trending Goldenville Formation rocks around the intrusive body, or that a single, or several pegmatitic dykes formed around the western terminus of the intrusive and are joined together. Information from the 2001 field season would suggest the latter (King, 2002, personal communication) The dykes north of the intrusion are also known to host beryllium (O'Reilly, 2002, personal communication).

Exposure is poor beneath the widespread overburden and vegetation in the area. The third (westernmost) outcrop and the surrounding area needs close evaluation to determine the orientation of pegmatite. An east - west orientation (such as the outcrops described by O'Reilly) would suggest the pegmatitic body is either offset around the western extremity of the parental magma, or several pegmatites inhabit the locale as a "swarm". A north - south orientation, along the steep ridge west of the seasonal stream, would suggest a pegmatitic body that envelopes the parental granitic intrusive on the western contact. Trenching in this area of the occurrence to expose the nature of pegmatite emplacement is recommended.

Ridges representing the parental granite of the pegmatitic body noted on the DEM suggest further areas ripe for investigation of more pegmatite development. One notable candidate is clearly revealed 750 m west - northwest of the current exploration target.

The increasing number of beryl-bearing float and outcrops at Lower Caledonia continues to be the main source of interest for investigators at this exploration target. The unidentified buff coloured mineral has SiO_2 and Al_2O_3 in the correct percentages for this mineral to be beryl. The remaining (missing) percentage of beam loss is attributed to the presence of Be, which is too light for probe measurement.

Seffernsville

There is obvious zoning in this pegmatite occurrence. However, the exposure is partially obscured and it is unknown whether the massive quartz veins represent more than one phase of pegmatitic zoning. The polished section data suggest that it does. The presence of rare lepidolite from pit dump material suggests evolution beyond purely a primary level. Massive quartz stockwork close to the occurrence suggests alteration, possibly due to shear deformation related to intrusive emplacement, or to regional deformation.

The host leucogranite of the Seffernsville pegmatite displays evidence of being a good parent magma for the formation of highly evolved pegmatites (Cerny, 1982). It displays structures suggesting partial local segregation and evolution of the magma within the body of the intrusive. The micro-brecciated fabric present in the polished section from Seffernsville, and seen in Figure 4, confirms the presence of a cataclastic fabric. Mineral phases seen under scanning electron microscope analyses follow this shear fabric, and mineral phases are relegated to veins and other replacement and invasion sites within a brecciated texture. Ilmenite and sphalerite have been identified under the scanning electron microscope, and may account for the unidentified dark, opaque minerals noted in hand specimens. The site continues to be of economic interest. The presence of lepidolite clearly identifies this occurrence as a highly evolved pegmatite that warrants further investigation.

There has been less field evaluation of the Seffernsville site than the Caledonia location. Further field investigation of the site as a possible beryllium - lithium and rare-earth element source at the prospecting level is warranted.

Acknowledgments

The writer wishes to acknowledge the assistance of Dr. Fred Breaks of the Ontario Geological Survey, Tracey Lefensky and George O'Reilly of the Nova Scotia Department of Natural Resources, and Steve King of Acadia University, for helping to provide background materials used in the interpretation of results and in the reference section of this report. Gordon Brown, of the Dalhousie University Microtech Lab, produced the polished sections. Bob MacKay set up quality control for the probe analysis and helped interpret results. Bruce Mitchell of Mercator Consulting accompanied the writer in the field at Lower Caledonia with the consent of mineral rights holder Steve King. Brian Paul (2000), John MacIsaac (2001) and Sean Moser (2001) accompanied the writer in the field at Seffernsville with the consent of mineral rights holders Brian Paul (2000) and Sean Moser (2001). Jeffery Poole (of Nova Scotia Department of Natural Resources) provided the raw DEM files used for data reduction for those sections of the report. Several figures in this report were modified from existing figures supplied by George O'Reilly, who also provided overall guidance.

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Mineral Inventory Studies in Mainland Nova Scotia for 2001

G. A. O'Reilly

Introduction

Mineral Inventory investigations on the Nova Scotia mainland in 2001 consisted primarily of field checking mineral occurrences in the Eastern Shore region (area east of Halifax) and an examination of deposits of the Fe-oxide-Cu-Co-Au association along the Cobequid-Chedabucto Fault Zone (Fig. 1). In addition, several rare metal occurrences in pegmatites and associated leucogranites on the Eastern Shore and southwest Nova Scotia were also examined.

A program of specialized Re-Os age dating of molybdenite, initiated jointly with D. J. Kontak (NSDNR) and S. Carruzzo (Dalhousie University) in 1999, was continued this past field season. A sample of molybdenite-bearing greisen from the Carboniferous Wedgeport Pluton near Yarmouth (Fig. 1) was collected and is currently being processed at the geochronology laboratory of the University of Calgary.

The Mineral Occurrence Database was updated from Version 4 to Version 5 in January 2002. The updated Version 5 files are currently available as a free-of-charge download through the Minerals and Energy Branch website (http://www.gov.ns.ca/natr/meb/) or at a minimal fee through the Department of Natural Resources library for a version on two 3.5" floppy disks.

Examination of the Fe-oxide-Cu-Co-Au Association

Several sites structurally controlled by faults within the Cobequid-Chedabucto Fault Zone were examined during the 2001 field season (Fig. 1). Mineral Inventory studies carried out over the past

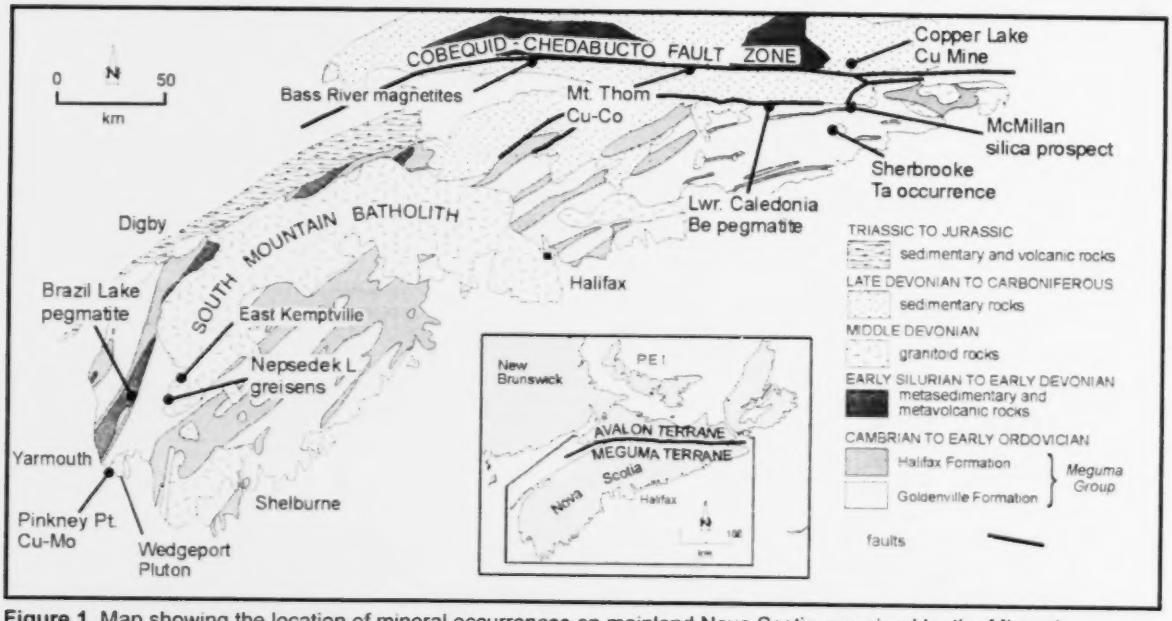

Figure 1. Map showing the location of mineral occurrences on mainland Nova Scotia examined by the Mineral Inventory Project during 2001. The area bounded by the major east-west faults that divide the Avalon and Meguma terranes (inset) is known as the Cobequid-Chedabucto Fault Zone.

several years have indicated that there is a potential for deposits of the economically important Fe-oxide-Cu-Co-Au association in Nova Scotia. The Fe-oxide-Cu-Co-Au association, or Olympic Dam-type deposits as they are sometimes known, are a diverse family of ore deposits, usually of massive size, that occur in a variety of geological environments and often display contrasting features from one another. However, they have several features in common, with perhaps the most notable being the presence of large amounts of Fe-oxide (hematite and/or magnetite) in their ores. During the 2001 field season, examinations were carried out at what are believed to be key examples of this association in the province: the Copper Lake Cu deposit, the Mount Thom Cu-Co prospect, and the Bass River magnetite deposits.

Copper Lake Cu Deposit

The Copper Lake Cu deposit consists of several fissure veins of siderite, chalcopyrite and pyrite up to 3 m thick that intrude faults in Lower Devonian sedimentary rocks in eastern mainland Nova Scotia (Fig. 2). The deposit was mined intermittently on a small scale in the last half of the 1800s and first decades of the 1900s. The veins were mined for their Cu content only, but intermittent exploration at the site since the production era has occasionally revealed that interesting Au levels (in the order of 1-4 g/t) exist in samples from the waste rock dumps.

In 1995, Alterra Resources Inc. drilled two diamond-drill holes at the deposit to further examine the Au potential (Black, 1996). The holes intersected siderite-sulphide veins and thick sequences of hydrothermally altered sediment containing pyrite. Levels of Au in the drill core were found to be low to slightly anomalous, but assays up to 1.5 g/t were obtained. The results for Au led Alterra to drop the property.

During the 2001 field season, diamond-drill core from the Alterra drillholes was examined and several mineralized intersections were sampled. This was done in order to analyze representative mineralized intersections for a suite of elements to assess the geochemical signature of the deposit. This will allow a comparison to what would be expected for typical Fe-oxide-Cu-Co-Au style mineralization. The geochemical analyses are not yet complete, but preliminary results indicate the mineralized intersections are Fe and Cu-rich, as would be expected, and enriched in Ni, Co and As.

Mount Thom Cu-Co Prospect

The Mount Thom Cu-Co-Au prospect, or Steele Run prospect as it is sometimes called, is located in eastern Colchester County about 1 km north of the Trans-Canada Highway at Mount Thom (Fig. 3). The prospect was discovered and explored by Imperial Oil Enterprises Ltd. during the 1970s (Mersereau, 1971). At that time, fracture- and

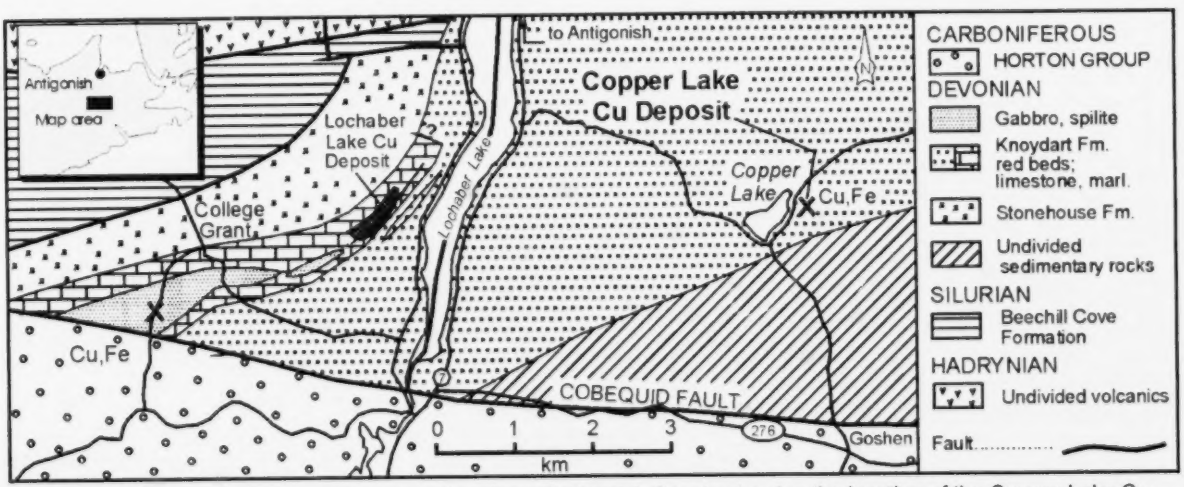

Figure 2. Geology and mineral occurrences of southern Antigonish County showing the location of the Copper Lake Cu deposit.

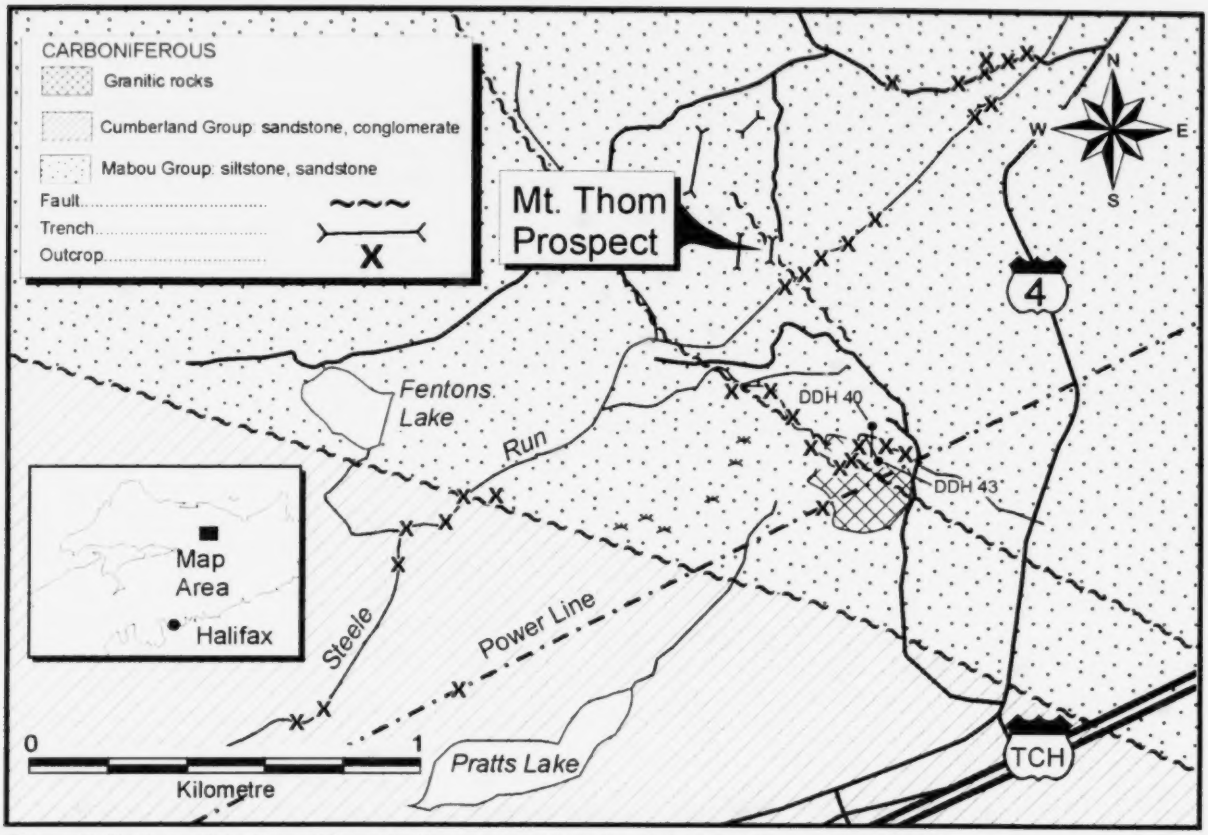

Figure 3. Geology of the Mount Thom Cu-Co prospect of eastern Colchester County, Nova Scotia.

breccia-controlled pyrite, chalcopyrite, specularite, hematite and ankerite were found related to northwest-trending splay faults associated with the major east-west sutures of the Cobequid-Chedabucto Fault Zone. In total, 49 diamond-drill holes (3 185 m) were drilled on the property. Originally, the prospect was explored merely for its Cu content and it wasn't until 1989 (Northcote *et al.*, 1989) that levels of Co into the thousands of ppm were recognized in mineralized outcrop and rubblecrop from the trenches.

A detailed field check of the Mount Thom prospect and an examination of several diamond-drill holes were carried out during the 2001 field season (Fig. 3). Particular attention was paid to the area south and west of the prospect, on the south side of Steele Run. That area has received a lesser degree of exploration even though there are indications in the assessment files that the rocks there display considerable faulting and hydrothermal alteration. A granite intrusion outcropping along a small tributary of Steele Run may have very important genetic implications. The contact relations of the granite with surrounding Carboniferous sedimentary rocks is not clear and has been complicated by extensive faulting. However, there is evidence in outcrop and in Imperial Oil diamond-drill holes 40 and 43 (Fig. 3) that suggest the granite actually intrudes the sediments. The presence of a granite of Carboniferous or younger age not only has genetic implications as far as mineralization is concerned, but also geological implications in general. From a geological viewpoint, an example of granite intruding Mabou Group sediments is noteworthy. A-type granite plutons (granites of alkaline character) yielding early Carboniferous radiometric age dates are known throughout the Cobequid Mountains (Pe-Piper *et al.*, 1991 and 1998), but nowhere are these seen in anything other than faulted contacts with Carboniferous rocks. Granite

actually intruding a mid-Carboniferous unit like the Mabou Group is presently not documented and would indicate felsic plutonism in Nova Scotia continued much longer than is currently thought.

From an economic viewpoint, a granite intrusion contemporaneous with faulting and mineralization at Mount Thom provides, at minimum, a major source of heat and, possibly, a source for the mineralizing fluids and/or metals. The presence of A-type granites in the Cobequid Mountains is of particular note. On a global basis, A-type granites are often thought of as being precursors for Fe-oxide-Cu-Co-Au deposits. The presence of such a pluton at Mount Thom is a further suggestion that the prospect has strong affinities to the Fe-oxide-Cu-Co-Au association.

Bass River Magnetite Deposits

Several magnetite occurrences were discovered by prospectors along the south margin of the Cobequid Mountains north of the village of Bass River, Colchester County, in the late 1930s (Fig. 4). At that time the deposits were considered for their steel making potential, but their high pyrite content rendered them unusable for that purpose. Lodestone Limited examined the occurrences between 1985 and 1989, carried out a six hole diamond-drill program, and collected a 2 000 tonne bulk sample on the Bass River property (Barrett, 1988). That prospect was deemed to have the most potential to produce a magnetite concentrate to meet the heavy media market. The Lodestone Limited evaluation recognized the presence of high Co in the mineralized rock and found it to be associated with the pyrite that is ubiquitous within the magnetite but occurs in variable amounts. Metallurgical tests carried out by Lodestone (Adorjan, 1987) indicated an average grade of 500 ppm Co for unprocessed rock mineralized with magnetite-pyrite, and 0.9% Co for the sulphide concentrate. Lodestone Limited (1987) reported the presence of interesting levels of Au (up to 2078 ppb) in the cobaltiferous pyrite fraction of the magnetite-rich rock. There was some question as to the validity of these high Au levels, so Lodestone carried out some follow-up analyses for verification and were unable to reproduce the results (A. M. Barrett, personal communication). Their conclusion was that the samples were contaminated during processing.

Four of the magnetite occurrences were field checked during 2001. Special emphasis was placed on an examination of the Bass River prospect and an adjacent magnetite zone exposed on the Bass River a few hundred metres to the east (Fig. 4). In addition, core from two of Lodestone Limited's diamond-drill holes from the deposit were examined and sampled. Preliminary geochemical analyses (analyses not yet complete) on several samples of magnetite-pyrite mineralization collected during the field checks returned high levels of Co similar to those reported by Lodestone. In support of the Lodestone conclusion regarding the presence of Au, the levels of Au from samples collected with this study were found to be anomalous (20-30 ppb), but not markedly so.

Field relations of the magnetite occurrences indicate that there was a strong structural control to their formation, related to movements on major sutures of the Cobequid-Chedabucto Fault Zone. Most of the deposits are hosted by siltstone and siliceous siltstone of the Carboniferous Londonderry Formation at, or very near, the faulted contact of this unit with the late Precambrian Great Village River Gneiss. The relationship of magnetite to layered carbonate that often is intimately associated with it is not clear at this time. The layered appearance of the carbonate suggests it may be a limestone unit within the Londonderry Formation, and that it may have acted as a chemical reactant and played a part in the precipitation of magnetite. Unfortunately, the carbonate is deformed and totally recrystallized so any original sedimentary features have been obliterated. An alternative interpretation is that the carbonate is a hydrothermal alteration product associated with magnetite formation and the layered appearance is due to a combination of deformation and flowage. The presence of strongly brecciated carbonate, still with layered form, suggests the layering is tectonic and not lithological. In addition, the fact that portions, or segments, of the layered carbonate occur within sections of massive magnetite that are clearly discordant with the predominant east-west trend of most of the carbonate unit again suggests that the

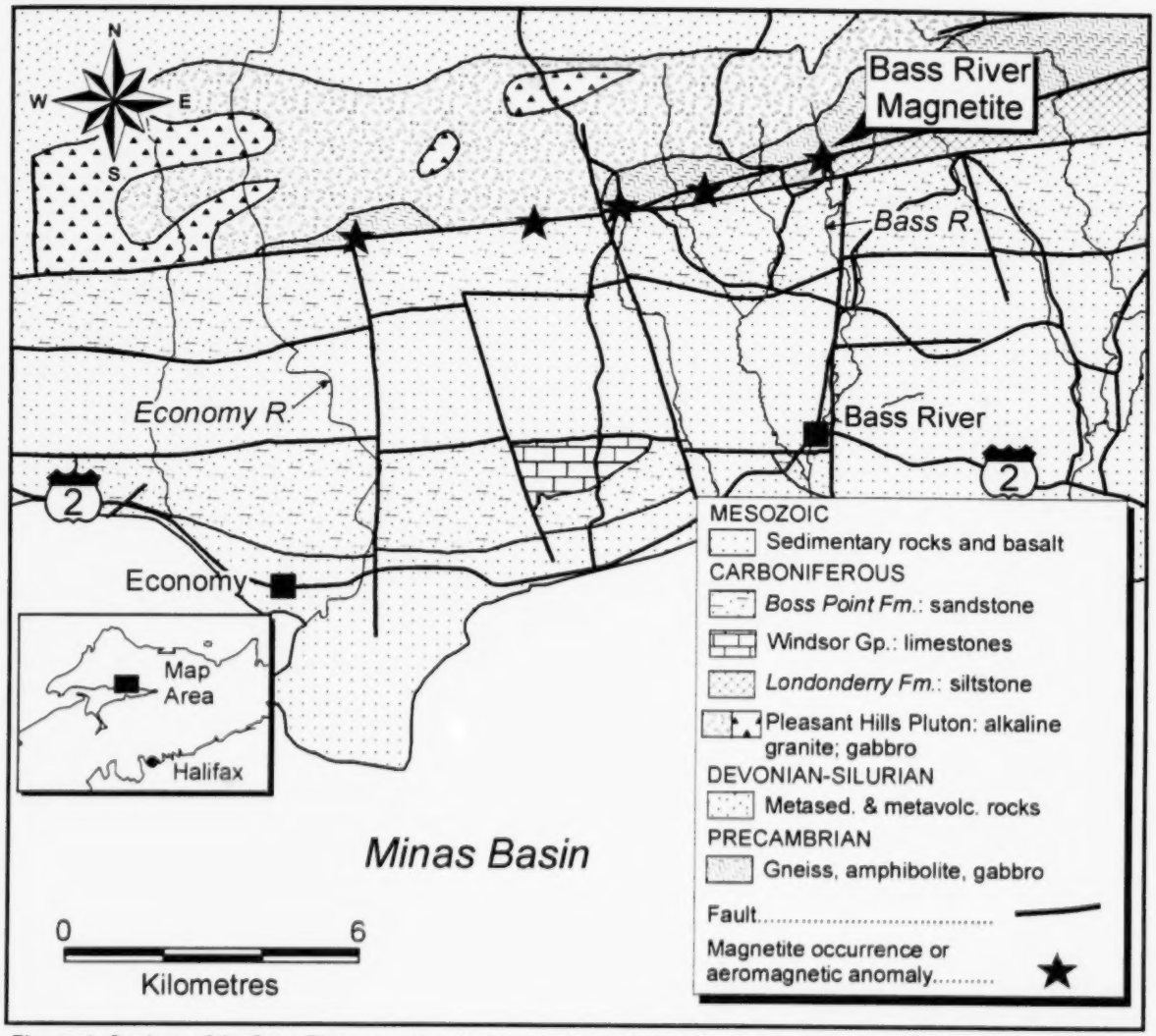

Figure 4. Geology of the Bass River area showing the location of magnetite occurrences associated with the Cobequid-Chedabucto Fault Zone.

carbonate is secondary and related to the mineralization processes.

As mentioned earlier, on a global basis Fe-oxide-Cu-Co-Au deposits are often genetically linked to A-type granite magmatism. The Carboniferous Pleasant Hills Pluton is found within a few hundred metres north of the Bass River magnetite occurrences (Fig. 4). Pe-Piper *et al.* (1998) determined the Pleasant Hills is a composite pluton ranging from gabbro to granite, and that the granitic portion is an alkali feldspar granite of A-type character. As a result, the relationship of magnetite mineralization to this pluton may be significant. Diamond-drilling has shown that breccia fragments of pink granite, identical to the Pleasant Hills granite, occur within the brecciated portion of the Bass River magnetite prospect. In addition, veinlets and small vug fillings of pink K-feldspar are also present. These features suggest that magnetite formation occurred during or after the Carboniferous intrusion of the Pleasant Hills Pluton, and that magnetite precipitation occurred under CO_2- and potassic-rich conditions.

Granite-hosted Rare Metal Deposits

Field investigations were carried out at several other sites throughout the mainland (Fig. 1) in 2001. These included several occurrences of pegmatite and associated leucogranites that have recognized, or potential for, rare metal mineralization. The high level of Ta at the Brazil Lake albite-spodumene pegmatite, Yarmouth County (up to 461 ppm), and the Sherbrooke Ta occurrence, Guysborough County (444 ppm), are of particular note given the current interest in this metal by the mineral exploration industry. Other sites with rare metal potential that were examined include (Fig. 1) a series of mixed pegmatite/ leucogranite dykes at Lower Caledonia (Lower Caledonia beryl pegmatite); a quartz-rich pegmatite at Country Harbour (McMillan silica prospect); and several recently discovered Zn-bearing topaz greisens with elevated Ta at Nepsedek Lake, Yarmouth County.

Re-Os Age Dating

A granite-hosted occurrence of Cu-Mo-Zn-bearing greisens within the Carboniferous Wedgeport Pluton at Pinkneys Point, Yarmouth County, was also visited. A sample of molybdenite-bearing greisen was collected for Re-Os geochronology as part of a joint, continuing effort to determine absolute ages of selected mineral occurrences in Nova Scotia with D. J. Kontak (NSDNR) and Ph.D. student S. Carruzzo (Dalhousie University). Molybdenite is naturally enriched in the radioactive element Re, but its inherent, insignificant amount of Os (i.e. Os present in the mineral when the mineral first crystallized) allows an assumption that essentially all the Os present in the mineral was derived by the decay of Re. This feature places molybdenite as a prime candidate for the direct dating of mineralization in deposits in which it occurs. The Wedgeport Pluton has a reported U-Pb age of 316±5 Ma (Cormier *et al.*, 1988), which places it as the only example of Carboniferous granite in southern Nova Scotia. Metasediment- and granite-hosted deposits of Sn and related elements occur within and around the pluton, and these are similar to those found in the endo- and exo-contact of the South Mountain Batholith in the East Kemptville area, some 40 km to the northeast (Fig. 1). However, the granite host rocks and primary Sn at the East Kemptville deposit yield well defined Devonian ages between 360 and 380 Ma. The current Re-Os dating effort is intended to further examine this contrasting age differential.

Version 5 Update of the Mineral Occurrence Database

The Mineral Occurrence Database was updated from Version 4 to Version 5 in January 2002. This update consists of a substantial amount of information compiled by the Mineral Inventory in predominantly two areas: south-central Cape Breton Island and the Eastern Shore region of the mainland. The Mineral Inventory input into the Targeted Geoscience Initiative (TGI) Project: Geological Mapping for Mineral Development in South-central Cape Breton Island consisted predominantly of information on industrial mineral occurrences in that region (see DeMont, this volume). The information included in the update for mineral occurrences from the Eastern Shore region consists of a mix of both metallic and industrial mineral occurrences.

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Deposits of Earthenware Clay in Southwest Cape Breton Island[1]

R. R. Stea, M. Feetham, S. E. Pullan[2] and W. Ostrom[3]

Abstract

There are abundant surface clay deposits in the lowlands of southwest Cape Breton Island with potential for use as low-temperature ceramic products. Large glacial lakes formed in the region at the end of the last glaciation when glaciers dammed up rivers flowing into the Gulf of St. Lawrence. Lowland basins adjacent to the Creignish Hills were filled with fine-grained, turbid sediment from eroding till deposits washed in by slope runoff and glacier melt in the highlands. The clay deposits found in these basins are unusually fine-grained and massive. They lack graded beds with coarse silt and sand strata that often characterize glacial lake sediments (varves), and have a low percentage of dropstones (dropstones are larger rocks that have been carried into the lake via floating ice or icebergs and later dropped by melting). The implication is that active glaciers were not directly calving into these bodies of water, but dammed the basin outlets at lower elevations. The age of the youngest of these ice-dammed lakes has been bracketed by an organic paleosol underlying lake clay at several localities dated around 11,200-10,800 ^{14}C years B.P. and regional basal lake sediment accumulation ages of around 10,000 yr BP. The last of these ephemeral ice-dammed lakes formed when a glacier in the Gulf of St. Lawrence re-advanced during the Younger Dryas period (11-10 ka), a brief but intense cold period at the end of the last glaciation.

Mapping and sampling of these clay deposits indicate that they are widespread, fine-grained and homogenous. Utilization of clay as a resource material for ceramics and structural products depends on a range of properties unique for each industry. A common denominator for all industrial clay uses is a large-volume source of moderately uniform clay that has a low shrinkage/swelling percentage, consistent firing colour, relatively low firing temperature, and good strength after firing. The initial firing tests show that these clay deposits are of the earthenware type, and meet the requirements of many low temperature ceramic products. They have excellent plasticity and good strength after firing. It appears from initial testing that the Cape Breton deposits are similar to Lantz clay, which is currently used for structural (brick-tile) material and pottery. More testing will be required to fully evaluate the clay, and a joint program to evaluate Cape Breton clay is being initiated with the Nova Scotia College of Art and Design.

Introduction

Earthenware clay is a brown, iron-rich clay that fires at relatively low temperatures (950-1100°C). It is used in pottery and as a base material for brick, roof and drain tile and other structural clay products. The earthenware clay deposits of southwest Cape Breton Island were deposited in glacial lakes formed at the end of the last glaciation by an ice dam in the Gulf of St. Lawrence.

The area of interest for this study includes parts of NTS map areas 11F/11 and 11F/14 in Inverness County, within the lowlands of the Gulf of St. Lawrence coast, east of the Creignish Hills (Fig. 1). This report will examine the distribution, origin and economic potential of these clay deposits. The project is funded through the Targeted Geoscience Initiative (TGI), and is aimed at stimulating resource development in Cape Breton Island by improving the geoscience knowledge base relating

[1]Contribution to the Targeted Geoscience Initiative project: Geological Mapping for Mineral Development in South-central Cape Breton Island.
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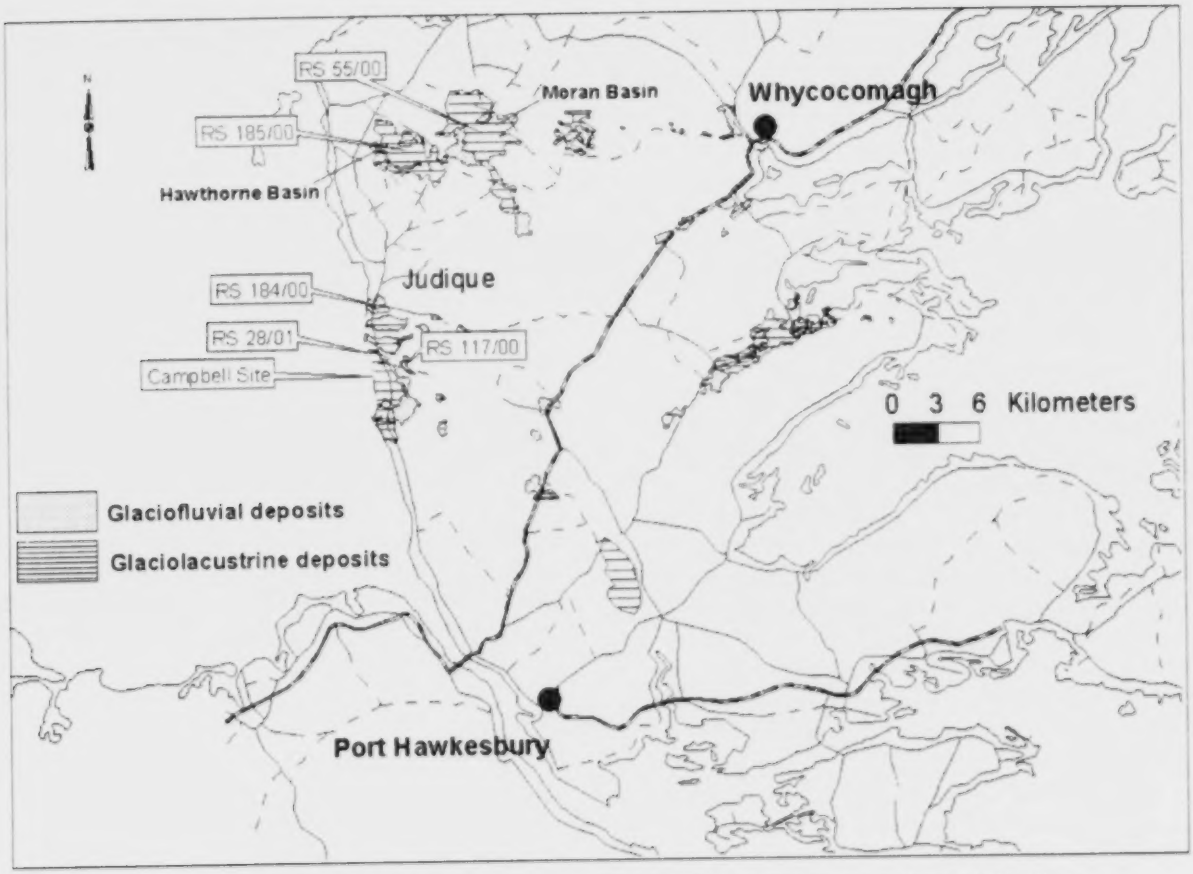


Figure 1. Map of southwest Cape Breton Island showing the main glaciolacustrine basins and sample locations.

to both the Carboniferous bedrock and the overlying Mesozoic and Cenozoic sediments in the area.

Methods

The techniques used to find and delineate these clay deposits include field mapping, shallow seismic methods, and rotary and auger drilling. In this study, extensive clay deposits were found using the following basic surficial mapping techniques.

1. Road, stream and coastline traverses to describe and classify the various types of surficial deposits. Hand augering to depths of 2 m with an Edelman Auger for stratigraphic information.

2. Air photograph interpretation and ground verification to delineate the areal extent of units and to match the surficial deposits (clay, till, sand, colluvium) with identifiable landforms.

3. Input into a GIS (ArcView®) data platform and integration with other data sources (previous maps, well log data, etc.) for final map production. Surficial soils maps by Cann *et al.* (1963) and a regional surficial map by Grant (1994) were used as base information to be built upon in this study. Many of the regions where the clay deposits were found were previously mapped as clay-rich till.

Seismic Surveys

The seismic testing program was designed to obtain

an estimate of the depth to bedrock at each site, and ideally, some information on the surficial stratigraphy at sites where drift thicknesses exceed 30 m. The methods and rationale are fully described in Pullan *et al.*, (2001). At each test site in this study area, data were acquired using an array of 24 geophones (Mark Products 50 Hz in marsh cases) at 3 m spacings (active spread length = 70 m), generally deployed along the roadside ditches. Wherever possible the geophones were planted in the bottom of ditches in order to improve the high-frequency response as a result of coupling to water-saturated sediments. The source was an in-hole "Buffalo gun" (Pullan and MacAulay, 1987), which fires a 12-gauge blank charge into the ground from 1 m below surface in a narrow-diameter, drilled hole (tamped with water). The data were recorded on a Geometrics Strataview RS-48 engineering seismograph, for shots fired at the midpoint of the array, and at 3 m, and 4.5 m off each end of the array (Pullan *et al.*, 2001). At some sites, additional records were acquired with shots 30 m off the end of the array.

Drilling Methods

Drilling was conducted using a track-mounted rotary (CME 99) drill. This multi-purpose drill allowed for a variety of sampling techniques, including augering, split spooning and coring. Standard augers with a 4.5 inch diameter were used to quickly drill down through surface clay, sand, and gravel. Grab samples were taken at 5 foot intervals from each auger. A 1.5 inch diameter, 2 foot long split spoon sample was obtained by driving a sampler ahead of the auger at the base of the hole. The drill was equipped with a 140 lb. hammer with a 30 inch drop. If ground conditions became unfavourable in materials or depth for auguring or split spooning, the drill was converted to diamond-drilling. Drillholes were cased with 3.9 inch HW steel pipe to keep the hole from caving in. An HQ core barrel and rods were used to obtain a 2.5 inch core sample. All holes were drilled vertically, and the casing was removed when the drillholes were completed.

Results

Figure 1 shows the surface distribution of glacial lake (glaciolacustrine) deposits, including massive clay. Glaciolacustrine deposits north of Judique infill bowl-shaped topographic lows informally termed the Moran and Hawthorne basins (Fig. 1). Near Judique, glaciolacustrine deposits are found along the coastal plain between the Creignish Hills and the Gulf of St. Lawrence. Sea-cliff exposures along the coast reveal four main facies: stony clay (diamicton), massive clay, laminated silty-clay/sand and laminated sand. In the northern Hawthorne Basin and Judique coastal plain, massive clay and stony clay appear to be the predominant facies. In the Judique coastal plain extensive sand deposits are associated with fine-grained deposits, both laterally and vertically.

Glaciofluvial deposits are found adjacent to and within the Moran Basin and the Judique coastal plain. These deposits consist of horizontally laminated, cobble-pebble gravel and gravelly sand (openwork and closedwork) and medium to coarse sand (sometimes cross-bedded).

Stratigraphy

Moran Basin Sections

Three drillholes (MB-01-1, 2, 3; Figs. 2, 3) were completed in the Moran Basin to determine the stratigraphic relationships between the coarse and fine deposits in the basin (Fig. 2). Six surficial stratigraphic units were delineated. The Quaternary section in drillholes MB-01-1 and MB-01-2 ends in micritic limestone at 13 m and 30 m, respectively. In drillhole MB-01-2 the limestone is underlain by grey-white gypsum. Resting on bedrock at both localities is a reddish-brown silty diamicton with local sandstone and limestone clasts interpreted as glacial till (Unit 1). Above the till is a cobbly-gravelly-sand unit with abundant greyish-white tonalitic pebbles, distinguished by epidote and altered mafic minerals (Unit 2 a). Overlying this unit in the deeper part of the basin is a sequence of grey and reddish-brown laminated and massive silty clay (Units 3a; 3b). At diamond-drill hole MB-01-02 a thick coarse unit overlies Unit depths >5 m below the surface, consisting of a bouldery gravel unit with granitoid clasts similar to Unit 2 (Unit 4b) grading into gravelly sand facies to the east (Unit 4a). The outcropping units consist of a

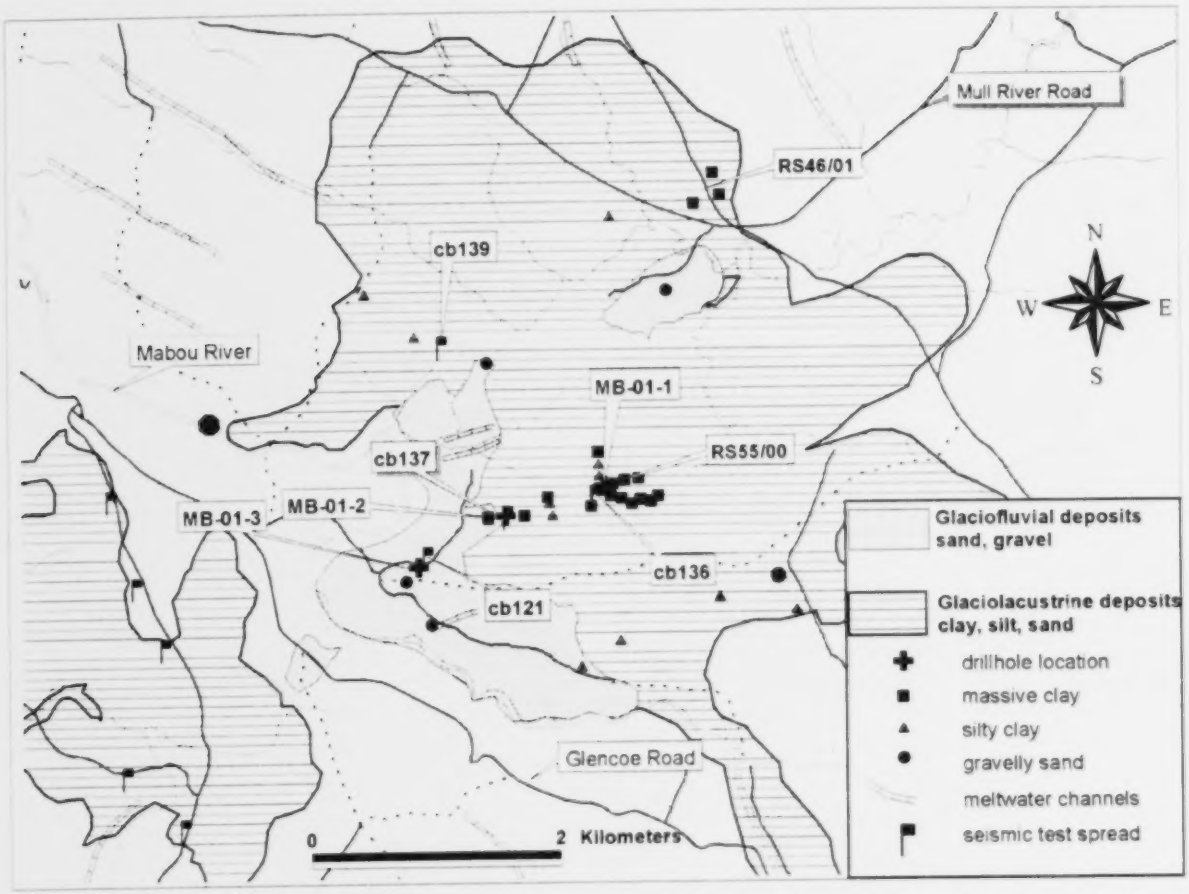


Figure 2. Close-up map of the Moran Basin, showing the locations of drillholes, seismic test spreads, and surficial data. Clay sample locations RS55/00 and RS46/01 are also shown.

laminated and massive reddish-brown silty clay and clay (Units 5a: 5b), found in the middle of the basin, and an overlying gravelly sand (Unit 6a) at the edges. These units appear to be separated by sharp, erosional contacts. Unit 5b is the massive clay facies most desirable for ceramics and is 6 m thick in drillhole MB-01-3 and 2 m thick in MB-01-1. Continuity between drillholes was established by many hand auger holes, which revealed clay at the surface over much of the Moran Basin (Fig. 2). The sandy mud (Unit 5c) at the top of drillhole MB-01-2 appears to be a lateral facies of Unit 5b, perhaps derived from reworking of nearby till highs. An added benefit of the Moran Basin clays is a lack of soluble salts and carbonates, which can cause scumming and bloating upon firing (Bell *et al.*, 1978). In many cases, applications of expensive and toxic chemicals are required to alleviate this problem. The clay deposit (Unit 5b) of economic interest increases in thickness from ~2 m in the east to ~15 m under glaciofluvial gravel deposits nearest the Mabou River (Fig. 2).

The seismic sections provide a further idea of the depth and continuity of glaciolacustrine facies, which include potential earthenware clay. Site 121 (Fig. 4) in the vicinity of drillhole MB-01-03 shows reflection energy at the top of the section, interpreted to result from a silt/sand layer within Unit 5b (9-13 m depth), underlain by a transparent facies to ~40 m depth. The reflection package at ~40 m depth is interpreted as the bedrock surface. The transparent seismic facies between 20 and 40 m depth probably represents fine-grained,

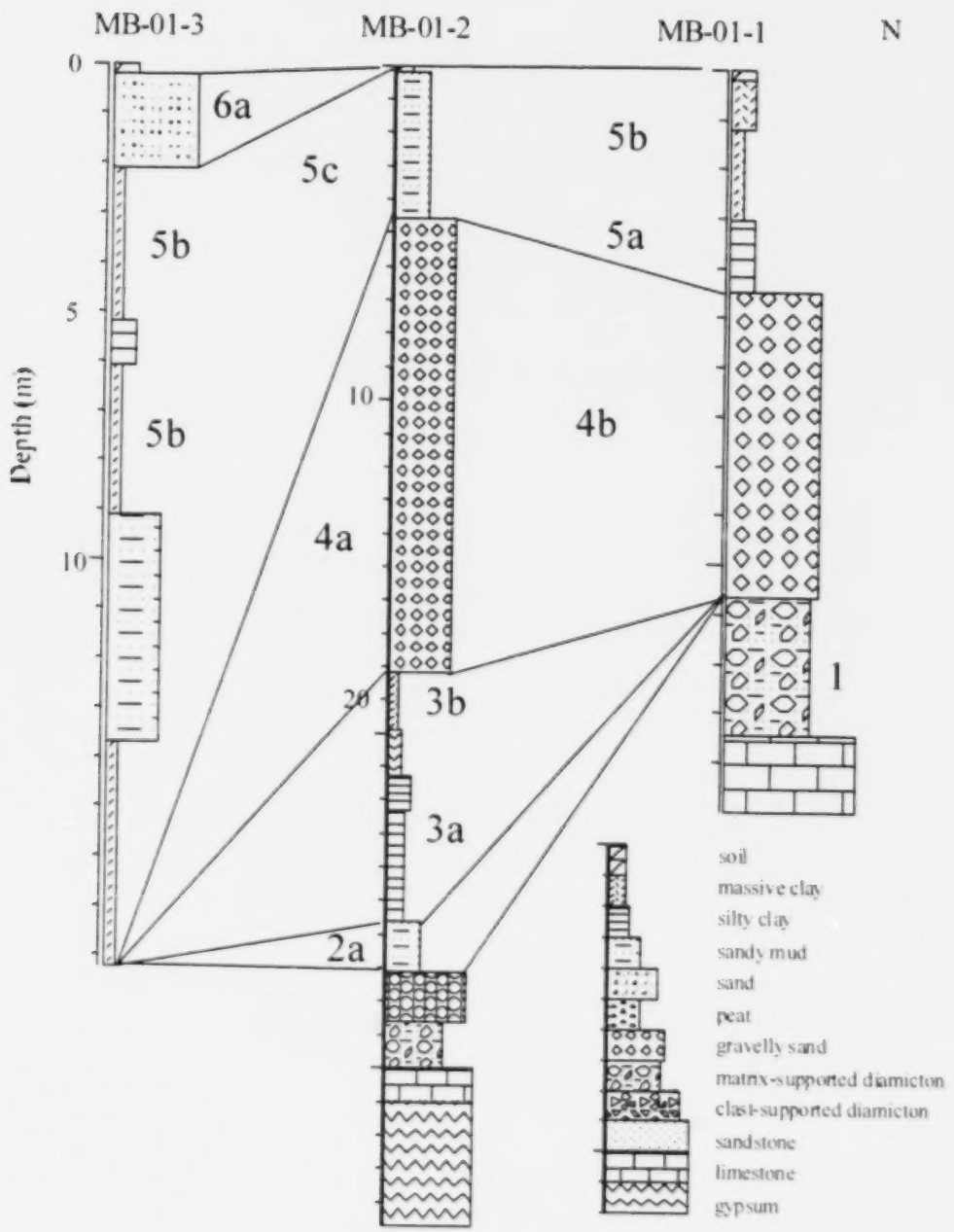


Figure 3. Drillhole transect across part of the Moran Basin showing the stratigraphic units and proposed cross-basin correlations. Unit descriptions are found in the text. Relative grain-size scale is shown by finer-grained sediments as thinner columns and coarser-grained sediments as thicker columns. Bedrock units are displaced farthest to the right. The vertical scale of section MB-01-02 has been adjusted to fit the page.

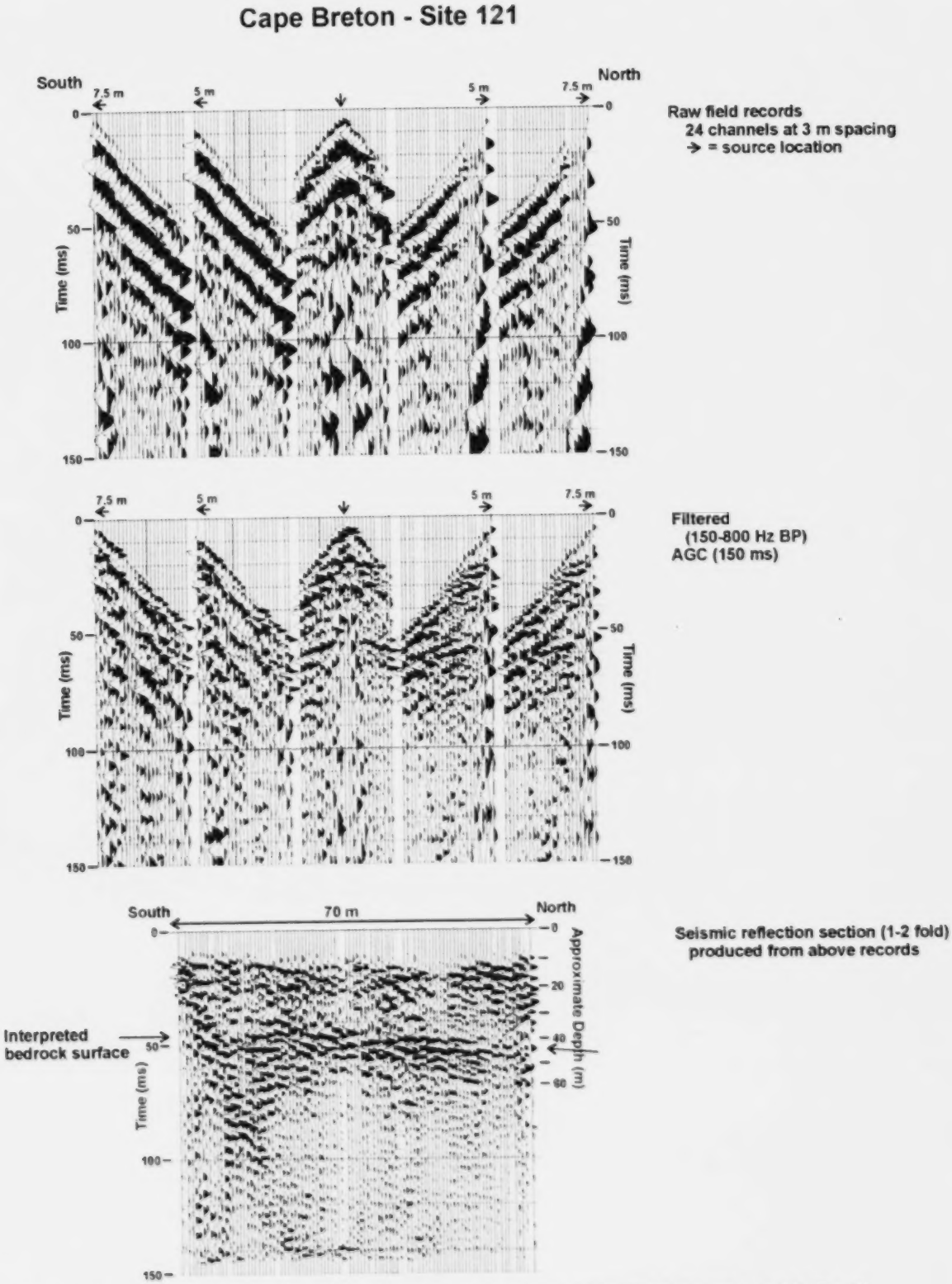


Figure 4. Seismic field records and resulting reflection seismic profile at seismic test spread site 121 (Fig. 2).

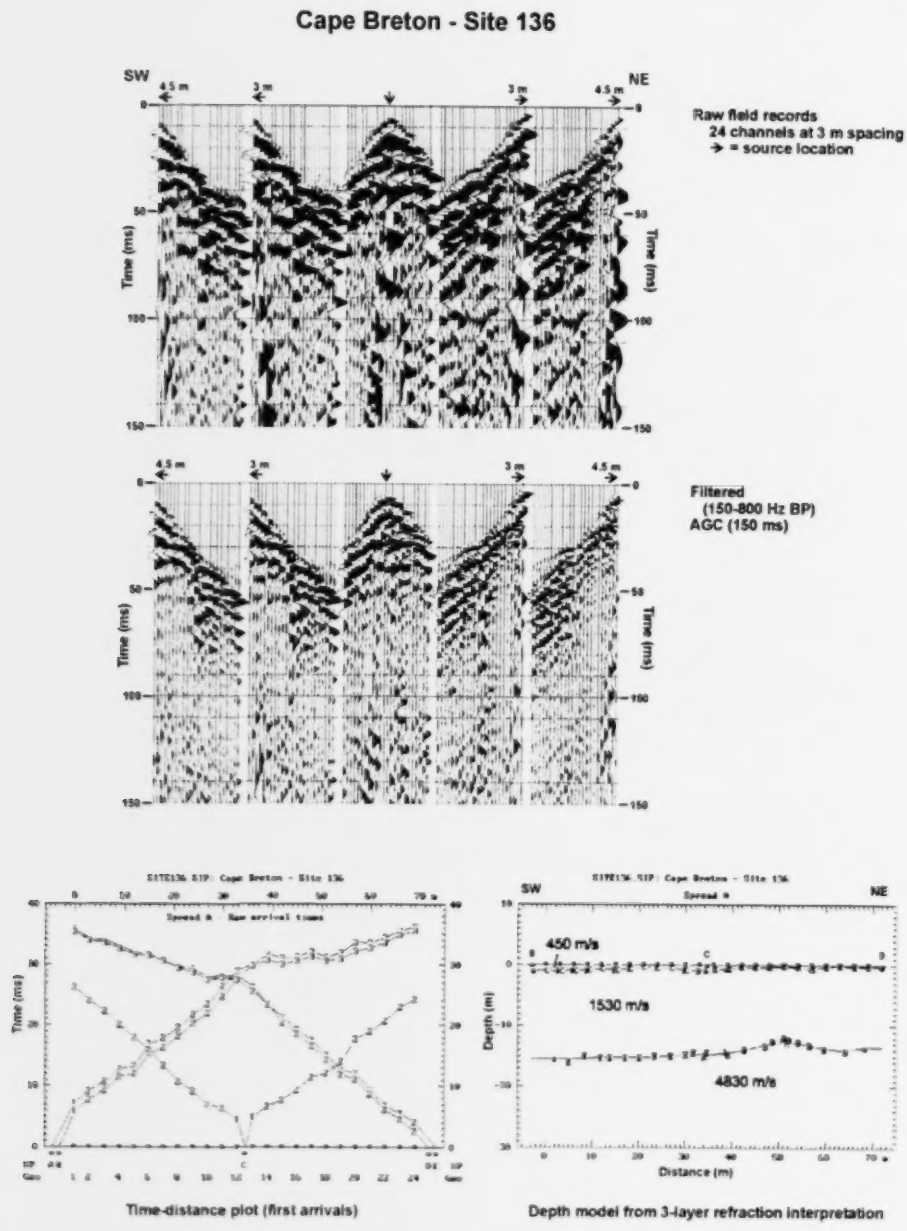


Figure 5. Seismic field records and refraction depth model at seismic test spread site 136 (Fig. 2).

massive facies below the 18 m thick section encountered in drillhole MB-01-03. Site 136 (Fig. 5) shows good data quality with a prominent refraction breakover, indicating shallow, high velocity bedrock at ~12-15 m depth. The drillhole record (MB-01-1) verifies the interpretation of shallow bedrock, and indicates that the overlying stratigraphy consists of low velocity sediments including clay (1530 m/sec; Fig. 5) and sand facies. Site 137 indicates a reflector at ~15 m depth, which corresponds to the boundary (sand/clay) between Units 3 and 4, and a deeper reflector at ~ 30 m depth, which is interpreted as the bedrock surface. Seismic data acquired at site 139 in the northern part of the Moran Basin (Fig. 6) are more difficult to interpret stratigraphically. At this site, seismic

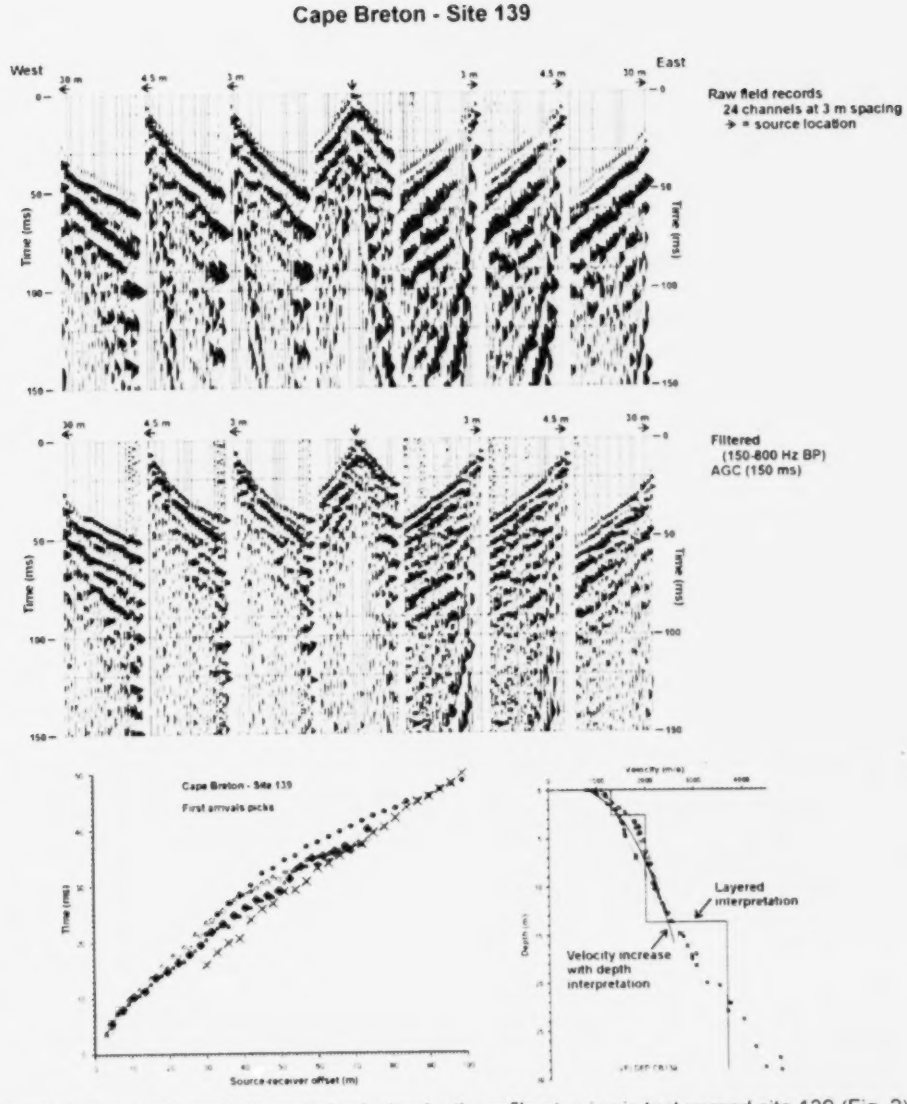


Figure 6. Seismic field records and interpreted velocity-depth profile at seismic test spread site 139 (Fig. 2).

velocity increases gradually with depth, and a layered refraction interpretation is likely a poor representation of the subsurface structure. Bedrock is estimated to be at ~15 m depth, based on the velocities determined there, but no high velocity breakover is observed. It is suspected that surface clay at this site may be underlain by coarser deposits (including perhaps sand, gravel and/or till), with little velocity contrast between these sediments and bedrock. The seismic section also implies that the bedrock in this area is not the high-velocity limestone observed at site 136.

Judique Coastal Plain Sections

Coastal exposures along the west coast of Cape Breton Island reveal a continuous unit of sand and clay (Unit 4) that can be traced laterally for 5 km and is draped over a peat layer, earlier glacial units and topography. At site RS28/01 (Centennial Road section) a continuous peat and clay organic paleosol (Unit 3) separates till, sand and clay facies from the upper draped unit (Unit 4; Figs. 1, 7, 8). The upper draped unit (unit 4) has two main facies: a parallel-laminated sand with thin beds consisting

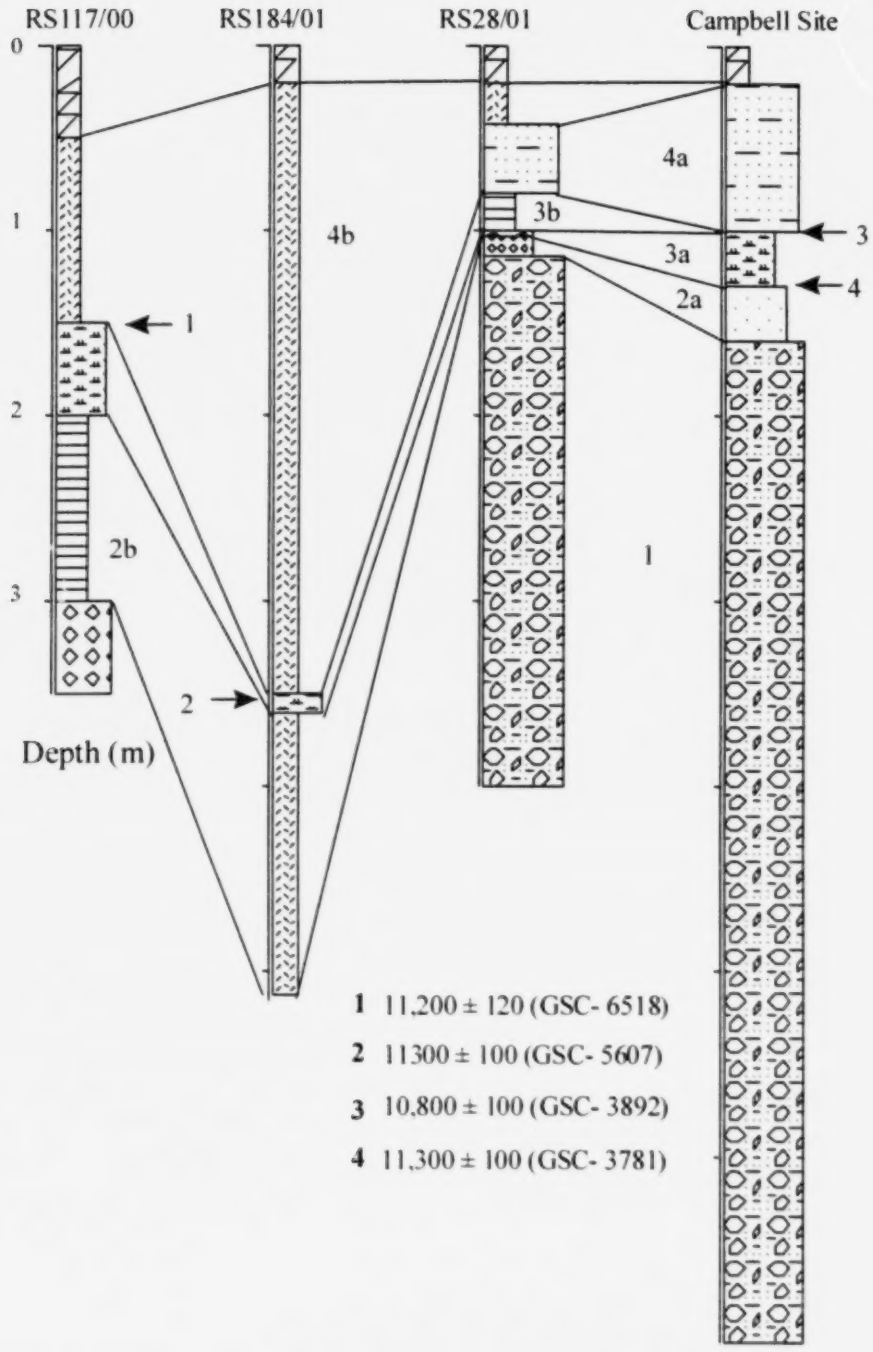


Figure 7. Stratigraphic sections in the Judique coastal plain area showing stratigraphic units and proposed cross-basin correlations. Unit descriptions are found in the text. Radiocarbon dates from the peat/organic marker horizon are shown. See Figure 3 for legend.

Figure 8. Sea cliff exposure after a severe winter storm November 7th , 2001. The Allerød peat/organic paleosol clearly stands out between the lower till and upper glaciolacustrine sediments (RS28/01-Fig. 7).

of normally graded coarse to fine sand (Unit 4a), overlain by a massive, red-brown, blocky silty-clay (Unit 4b). Farther north along the coast, the sandy facies of Unit 4 pinches out over silt/clay rhythmites and bouldery-gravelly sand. The Campbell site (Fig. 1), discovered by D. R. Grant in 1970, reveals an organic zone, overlain by a massive sand unit and underlain by sand and till (Grant, 1994; Fig. 2). The sand unit was originally interpreted as glaciofluvial, but the lateral and vertical interfingering relationships with clay units and normally graded sand beds suggest a subaqueous origin.

Glaciolacustrine sediments overlying the peat (paleosol) marker horizon can be traced inland near Judique South to elevations of between 60 and 70 m (Fig. 1). At site RS117/01 (Fig. 7), 1 m of brown, massive and laminated silty clay (Unit 4b) overlies peat (Unit 3a). A sandy clay unit (Unit 2b) underlies the peat/organic marker, resulting from earlier glacial lake deposition. This section is nearly identical to one described in the town of Judique (RS184/01; Stea and Mott, 1998) where as much as 3.4 m of massive clay (Unit 4b) was found overlying a thin peat layer, below which there is a glaciolacustrine clay (Unit 2b).

Interpretation

The clay units (Units 3 and 5) found in the Moran Basin are unusually fine grained and massive. These clay facies have a variable pebble content interpreted as dropstones, clasts that have been carried into a lake via floating shore ice and later dropped by melting. Active glaciers were not directly calving into deep bodies of water, because a nearby grounded glacier would produce rhythmic bedding or varves (Ashley, 1995). No linear iceberg scouring was evident from air photographs,

either. The deposits were probably formed in a relatively shallow lake that was dammed by stagnant ice at lower elevations. Meltwater channels can be traced to the former water base level at the basin edges (Fig. 2). Coarse, openwork, gravelly sand deposits (Units 2, 4 and 6) in sharp, erosive contact with lower and upper clay units, appear to have been deposited subareally when the lake had drained. The lack of interfingering of coarse and fine facies and absence of clinoform strata suggest that deltaic processes were not responsible for the facies architecture. Rather, the basins were periodically infilled with coarse glaciofluvial deposits upon ice retreat, and when glaciers advanced over outlet areas ice marginal lakes formed and fine-grained sediments were deposited. The abundance of tonalitic pebbles almost certainly suggests erosion by glaciers to the north in the Mabou Highlands, source of the granitic pebbles (Barr and Macdonald, 1989). Lynne Baechler (personal communication, 2001) also noted abundant coal in ice contact deposits in the Lake Ainslie region, thought to be derived from a glacier to the north in the Gulf of St. Lawrence.

Fine-grained surface deposits in the Judique coastal plain (Unit 4) overlying the organic paleosol marker horizon are draped over topography, also indicating subaqueous marine or lacustrine sedimentation. Marine deposition can be ruled out based on the known relative sea level (RSL) history of the region and the altitude of the clay deposits (+60 m). After 12,000 yr B.P. sea levels had dropped to between 50 and 100 m below present in the Gulf of St. Lawrence (Josenhans and Lehman, 1999). In addition, the organic paleosol beneath the clay sediments would imply a precipitous drop and rise in RSL not documented elsewhere in the Gulf. The openwork gravel and interfingering rhythmites in the lower glaciolacustrine sediments (Unit 2) are characteristic of proximal subaqueous fan deposits and distal glacial lake-bottom sediments (Ashley, 1995).

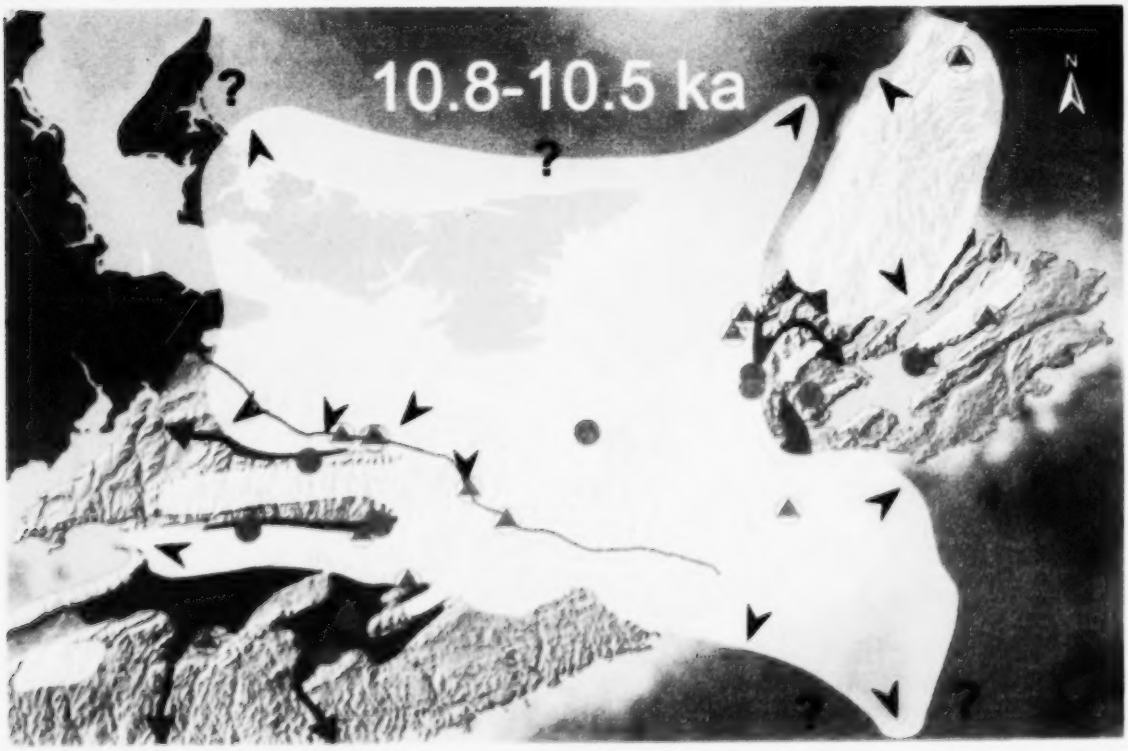
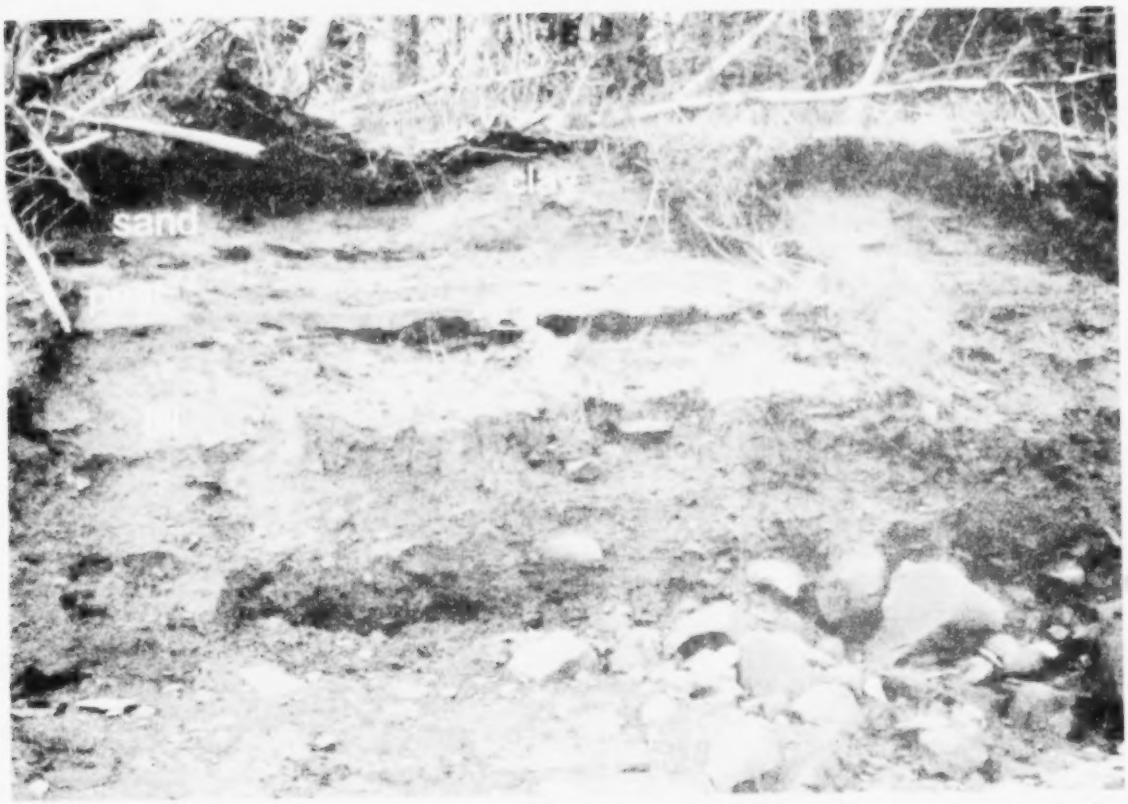


Figure 9. Schematic illustration showing the extent of glaciers (grey) during the Younger Dryas period ca. 10.8-10.0 ka. Triangles represent sites where till has been found over an Allerød paleosol. The dots are sites where glaciolacustrine sediments are draped over the Allerød paleosol. Glacial lake outlets and drainage are shown by arrows.



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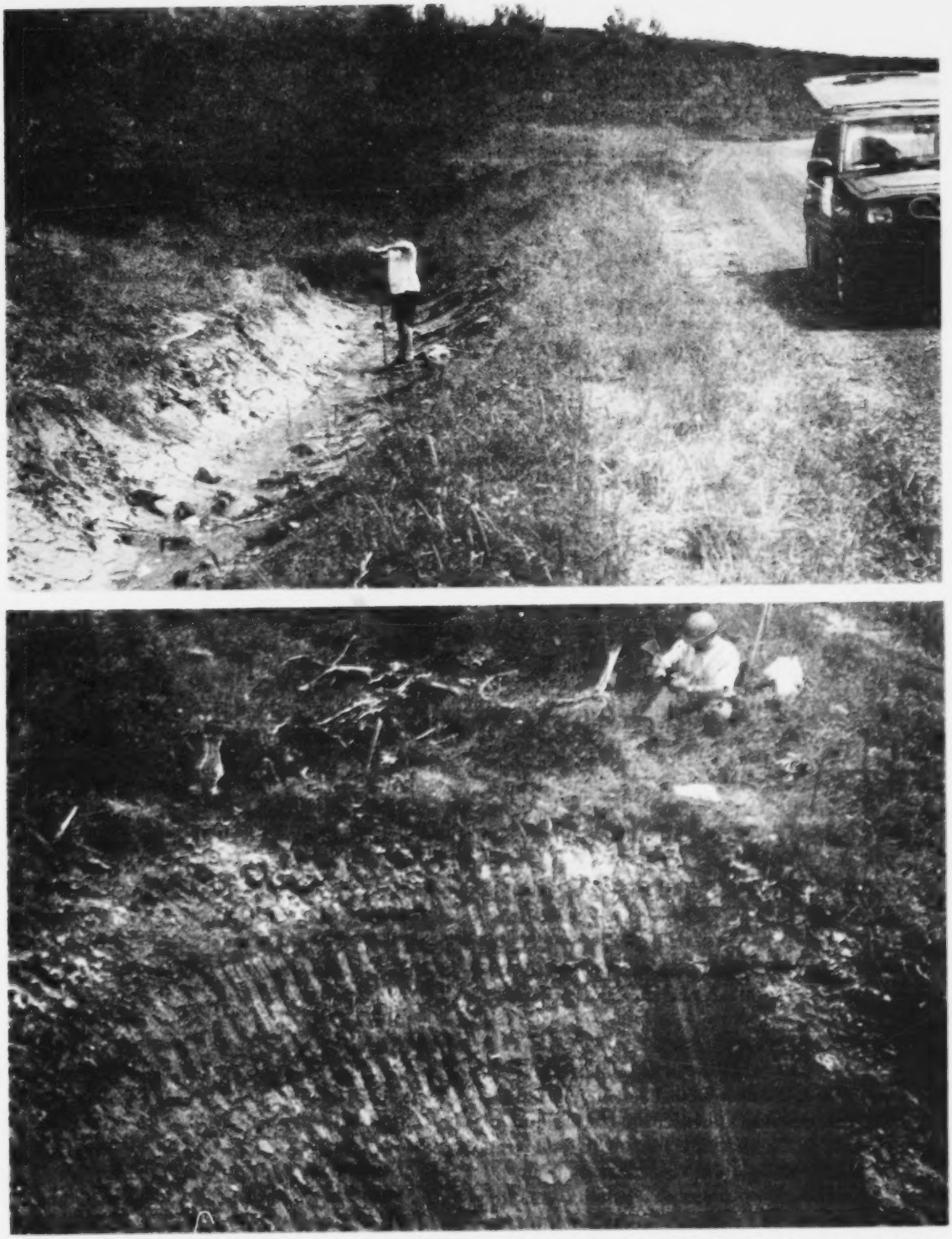

Figure 10. (a) Photograph of surface-outcropping earthenware clay and hand augering (unit 5b) in the Moran Basin near the Mull River road (site RS 46/01; Fig. 2). (b) Excavation of earthenware clay for samples at site RS55/00 (Fig. 2).

In order to impound a body of water to a level of 60-70 m against the Creignish Hills, a glacier must have existed in the Gulf of St. Lawrence, as was postulated by Grant (1994). Horizontal lamination and graded beds in the sand facies of the upper glaciolacustrine unit (Unit 4) suggests deposition from suspension in a distal glacier setting, but the associated massive clay facies are puzzling. These lakes may have been in a supraglacial position resting over a low-profile glacier within the Gulf of St. Lawrence shelf and over a deglaciated coastal plain. Stea and Mott (1998) identified two phases of glacial lake development termed Glacial Lake Dawson 1 and 2, using Grant's (1994) lake phase terminology. The glaciolacustrine deposits above (Unit 4) and below (Unit 2) the peat/organic marker bed of Allerod age (11-12 ka B.P.), suggest that lakes formed first upon ice retreat and later by advancing ice. Figure 9 shows the proposed extent of ice advance during the Younger Dryas glaciation after 10,800 yr B.P. and the position of glacier lakes.

The sequence of events can be summarized as follows:

1. Ice retreat ca. 12-11.5 ka during the Allerod warm period and the development of Glacial Lake Dawson, (1), perhaps localized in several inland basins including the Moran and Hawthorne basins.

2. Drainage of Glacial Lake Dawson (1) and ice retreat with small ice caps localized in the emergent Gulf of St. Lawrence and on the Cape Breton Highlands. Biota migration onto the deglaciated landscape ca. 11.5-10.8 ka.

3. Climate cooling and increasing storm intensity. Advance of a remnant ice cap in the Gulf of St. Lawrence. Formation of Glacial Lake Dawson (2) ca. 10.8-10.0 ka.

4. Drainage of Glacial Lake Dawson (2). Climate amelioration after 10.0 ka.

Economic Geology

From initial mapping and sampling it was determined that clay deposits identified in the study are fine-grained and homogenous (Figs. 10a and 10b). Utilization of clay as a resource for ceramics and structural materials depends on a range of properties unique for each industry. For example, a brick manufacturer wants a large-volume source of moderately uniform clay that has a low shrinkage/swelling percentage, consistent firing colour, relatively low firing temperature, and good strength after firing.

Clay mineralogy was determined through differential thermal analysis (methodology described in Fowler, 1972). Exothermic and endothermic reactions (heat loss and gain) produce positive and negative peaks on a curve that can be compared to standards and known clay specimens. There is a strong endothermic peak at 500-600°C, indicating dehydration of illite, probably the most abundant clay mineral (Fig. 11). The broad shoulders and secondary peaks on the DTA curve around 750°C indicate a mixture of clay minerals, perhaps chlorite, and minor carbonates (Bell *et al.*, 1978).

Initial results of ceramic testing (Hocking Technical College, Ohio) from samples of three separate glacial lake basins are shown on Table 1, with sample locations shown on the deposit map (Fig. 1). The dry shrinkage (DR) represents the size ratio before and after drying, whereas the fired shrinkage (TS) represents the form changes after firing to 1027°C (1880°F-Cone-04). Modulus of rupture (MOR) is a measure of tensile strength in pounds per square inch (PSI). Absorption or vitrification (V) is a measure of pore space reduction during firing. It is also called "boil absorption" and is measured by boiling a fired bar for two hours and measuring the weight gain of absorbed water.

The data show strikingly similar test results from the separate glacial lake basins defined on the map. Plasticity, shrinkage and absorption (vitrification) are within defined values for a good earthenware clay (Rhodes, 2000). The tensile strength parameter (modulus of rupture) shows fired values of >3000 psi, a value suitable for many structural products.

Table 2 shows the results of a similar testing program carried out by students of the Nova Scotia

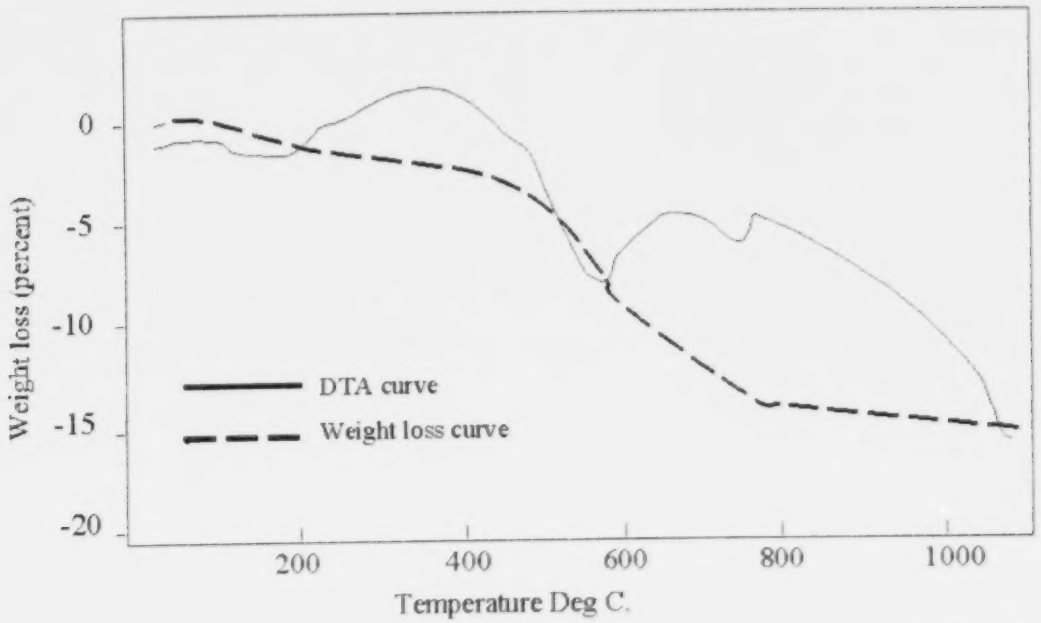

Figure 11. Differential thermal analysis (solid line); (DTA curve) for Unit 5b (Moran clay) at site RS 55/00 (Fig. 2). Weight loss curve for the same sample (dashed line).

College of Art and Design (NASCAD) under the guidance of Walter Ostrom. The student testing was conducted over a range of temperatures, from Cone 08 (945°C) to Cone 6 (1190°C). Results from the ceramics laboratory and student testing are compatible. The Cape Breton samples were compared to a known producing clay from Lantz, Nova Scotia. The water of plasticity is the per cent of water necessary to develop optimum plasticity in clay, and is an indicator of the particle size of the clay: the finer the particle size the more plastic the clay. The water of plasticity values (30-34%) indicate that the grain size of clay from the Moran Basin (RS55/00; Figs. 1, 2) is nearly 100% less than 2 microns (Grim, 1962). These initial results suggest that the Moran clay (#55) is close in physical properties to the Lantz clay, which is currently in industrial and pottery use.

As stated above, the initial mapping results suggest a very large, homogenous clay body. Additional mapping has discovered similar basins in southwest Cape Breton Island yet to be evaluated. If the clay properties are relatively uniform within the most promising basin to date (Moran Basin RS-55/00), then an economic deposit is possible. The shrinkage and absorption values are well within specifications (Gouthro, 1989) for a number of structural clay products including common brick, floor tile and pipe. More testing is required to determine the viability of the clay for structural clay products. The homogeneity of the body will allow for mixing with other clay and silica fluxes (grog) for modification of properties to suit detailed needs (Bell *et al.*, 1978). Prices of raw earthenware clays range from $100-300/ton US.

Acknowledgments

I would like to thank Terry Goodwin for his able assistance in the field when the initial discoveries were made, and for editing the manuscript. Also, many thanks to Mark Ferry, Adam Szcank and Tanya Costain for field assistance.

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Table 1. Analytical results from Hocking Technical College, Ohio. DS-Dry shrinkage. TS-Fired Shrinkage, V-absorption or vitrification, C-04, cone 04, MOR-Modulus of Rupture, (psi) pounds per square inch. Sample locations on Figures 1 and 2.

Clay test type	Clay test type	Clay test type	Clay test type
% Moisture	2.0	6.6	3.0
% Moist extruded	21.5	20.8	5.52
%DS	5.52	4.98	4.52
% TS C-04	10.14	9.98	9.23
%V C-04	8.3	7.5	7.7
% Porosity	17.8	16.1	16.6
Dry MOR (psi)	439.2	550.2	488.3
Fired MOR (psi)	2975.3	3474.4	3174
% Density	2.1	2.18	2.17

Table 2. Analytical results from the College of Art and Design. P-Plasticity, VG-very good, H_2O of P- water of plasticity, DS-Dry shrinkage. TS-Fired Shrinkage V-absorption or vittrification, C-04, cone 04. Sample locations on Figures 1 and 2.

Clay test type	RS-185/00	RS-55/00	Clay-Lantz
P	VG	VG	VG
% H_2O of P	28	34	33
% DS	5	8.70	5.20
% TS C-08	7.11	5.13	6.33
%V C-08	14.32	10.29	14.39
% TS C-04	10.10	10.76	10.88
%V C-04	8.03	6.85	6.29
% TS C-1	14.00	15.90	13.40
%V C-1	0.06	0.75	0.16
% TS C-6	-	-	-
%V C-6	-	-	-

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Stratigraphy of the Horton Group, Guysborough and Antigonish Counties[1]

P. J. Tèniére[2], P. S. Giles[3] and R. D. Naylor

Introduction

The Nova Scotia Department of Natural Resources (NSDNR) and the Geological Survey of Canada (GSC-Atlantic) are working together to complete a 1:50 000 scale geological map of NTS area 11F/11. This work forms part of a federally funded Targeted Geoscience Initiative (TGI) to evaluate the mineral resource potential of southeastern Cape Breton Island and the Strait of Canso area. Concurrent with the TGI project is mapping undertaken by Paul Tèniére, in support of his M.Sc. thesis, on parts of NTS areas 11F/05, 06, 11, 12 and 11E/08 (Fig. 1). Collectively, these two projects have afforded the opportunity to carry out a detailed analysis of the stratigraphy and structure of the Horton Group in Antigonish and Guysborough Counties. This report summarizes the preliminary results of work in the southwest corner of NTS 11F/11, and the additional area covered by Tèniére's thesis.

General Geology

The Horton Group is a Late Devonian to E rly Carboniferous (Tournasian) siliciclastic succession that can be found throughout the Maritimes Basin of eastern Canada. Sedimentation took place in a series of sub-basins that include localized fault-bounded half-grabens (Kilfoil, 1988; Hamblin and Rust, 1989; Miller *et al.*, 1990, Durling and Marillier, 1993; Martel and Gibling, 1996; Pascucci *et al.*, 2000) and more regionally, extensive "sags" (Durling and Marillier, 1993). Despite being relatively isolated from each other, many of the Horton sub-basins have broadly similar basin-fill patterns suggesting that sedimentation was influenced by regional tectonic processes (Martel and Gibling, 1996). In general the basin-fill consists of an upper and lower alluvial-fluvial succession separated by a lacustrine unit (Murray, 1960; Hamblin and Rust, 1989; Martel and Gibling, 1996). Fluvial and lacustrine deposits commonly coarsen laterally toward basin margins where they become interbedded with alluvial fan deposits (Hamblin and Rust, 1989; Murphy and Rice, 1998).

The Horton Group exhibits considerable thickness variation both within and between sub-basins. Thickness estimates for the Horton Group in the type area along the Minas Basin range from 600 m (Martel and Gibling, 1996) to 1150 m (Bell, 1960). The Horton Group is reported to be approximately 2500-3500 m thick in the following basins: St Mary's Basin (Murphy and Rice, 1998), sub-basins along the west coast of Cape Breton Island (Hamblin and Rust, 1989), and half-grabens in the Gulf of St. Lawrence region (Durling and Marillier, 1993). Based on seismic data, Durling and Marillier (1993) interpret that 8000 m of Horton Group strata may be contained in the Malpequec sub-basin in the Gulf of St. Lawrence. However, this unusual thickness may reflect structural thickening or the possible inclusion of pre-Horton Group strata (Durling and Marillier, 1993).

Previous Work

The area covered by this report is bounded by the Glenroy Fault to the north, the Roman Valley Fault to the south, the Canso Strait in the east, and the Lochaber Lake Fault in the west (Fig. 2). The stratigraphy of the Horton Group in this area is difficult to model because the strata are complexly folded, have a well-developed cleavage, and are cut

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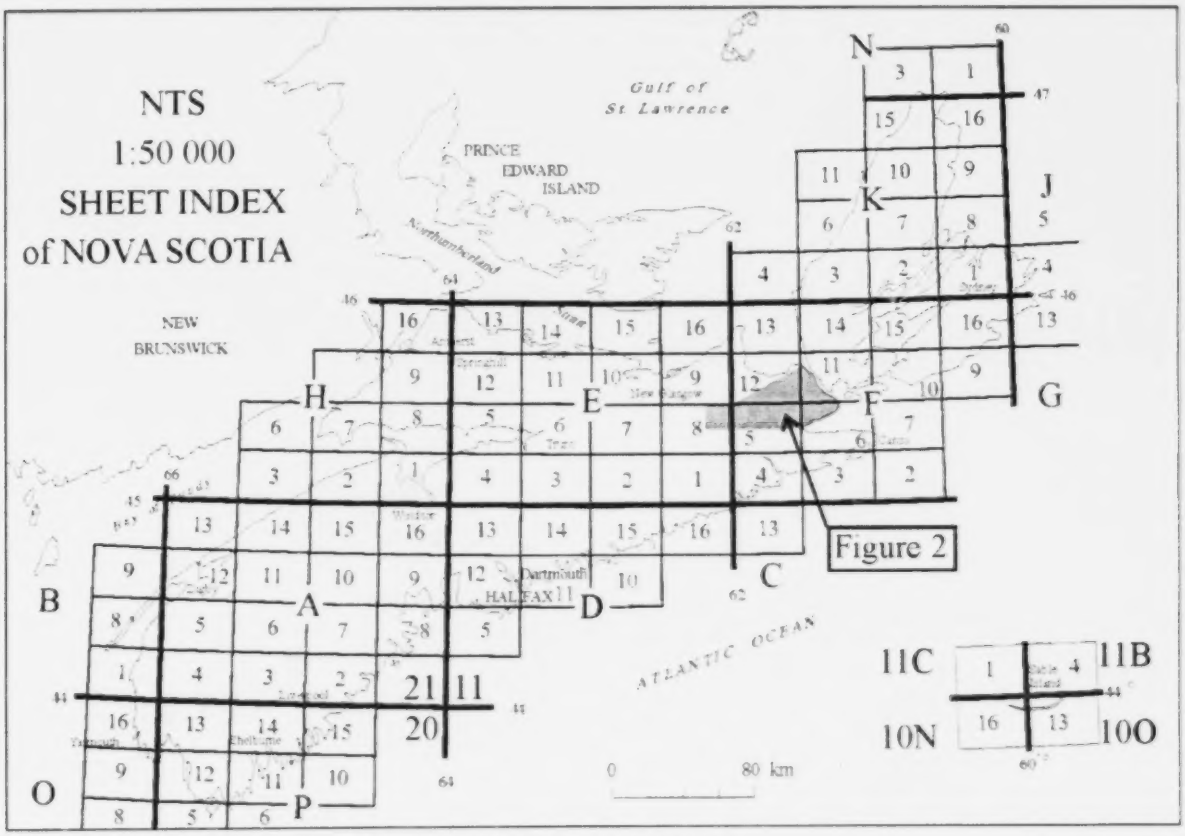

Figure 1. NTS index map of Nova Scotia, showing location of the study area.

by major faults. In addition, the thermal maturity is high, making it very difficult to recover palynomorphs that are suitable for rigorous biostratigraphic assessment. With the exception of a regional mapping project undertaken by White and Barr (1998a, b), previous workers have not examined the entire study area.

Ferguson (1946, 1950) provides detailed outcrop locations as well as useful structural and lithologic information on NTS area 11F/11. However, Ferguson did not suggest any formal lithostratigraphic subdivisons of the Horton Group. Schiller (1961) used colour as a basis to informally subdivide the Horton Group strata on the north half of NTS 11F/05 into three units. No formal nomenclature was proposed and the units were simply identified from the base to the top of the succession as Unit 7Ac (grey and grey-green), Unit 7Ab (maroon and grey) and Unit 7Aa (maroon). Benson (1970) proposed similar subdivisions for Horton Group strata on the west half of NTS 11F/12. Benson (1970) recognized a lower grey unit (Unit 5) and an upper redbed unit (Unit 6).

Based on mapping parts of NTS sheets 11F/05 and 11F/06 (Fig. 1), Smith (1980,1981, and Smith in Williams *et al.*, 1985) subdivided the Horton Group into five informal formations. In ascending order these include: the Glenkeen, St. Francis River, Clam Harbour River, Tracadie Road and Hadley Cove formations. The lower two formations, the Glenkeen and St Francis River, were considered by Smith (1980, 1981) to be lateral equivalents. These two units have a combined thickness of approximately 670 m and consist of grey conglomerate and sandstone with minor siltstone. The overlying Clam Harbour River Formation is approximately 1300 m thick and consists of greenish-grey siltstone with thin interbeds of dolomitic limestone. The Tracadie Road Formation is approximately 6000 m thick and

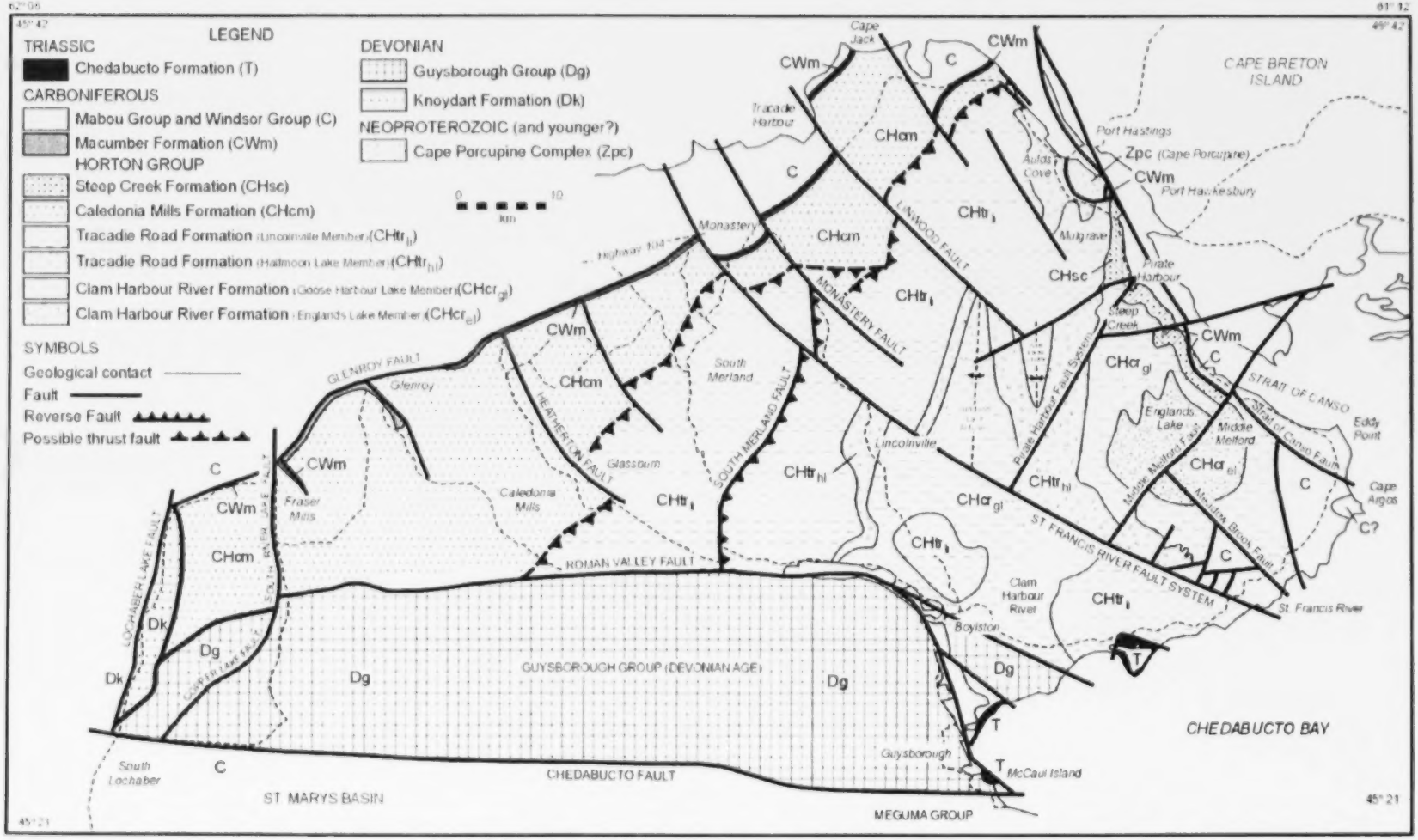

Figure 2. Simplified geological map of the Lochaber - Mulgrave area, northern mainland Nova Scotia.

is in gradational contact with the Clam Harbour River Formation. Smith described the Tracadie Road Formation as blue-grey thinly laminated siltstone with local sandstone and rare conglomerate interbeds. Smith (in Williams *et al.*, 1985) gives a minimum thickness of 850 m for the Hadley Cove Formation. Brown sandstone interbedded with red and green mudrocks form the upper Hadley Cove Formation while the lower Hadley Cove consists of dark grey shale and siltstone interbedded with thin calcareous siltstone.

White and Barr (1998a, b) undertook a regional study of the Horton Group that included all of the current study area and parts of southern Cape Breton Island. Based on this work they re-assigned the Glenkeen Formation to the Middle Devonian Guysborough Group, retained the Clam Harbour River and Tracadie Road formations, and proposed the term Caledonia Mills Formation for the redbed succession at the top of the Horton Group. No thickness estimates were provided by White and Barr (1998a, b).

Stratigraphy of the Study Area

Within the study area the Horton Group occurs in faulted contact with Neoproterozoic metavolcanic, metasedimentary and granitoid rocks of the Cape Porcupine Complex (Fig. 2) (White *et al.*, 2001), Devonian metasediments and volcanics of the Guysborough Group (Cormier *et al.*, 1995) and Devonian siliciclastics of the Knoydart Formation. The Horton Group is disconformably overlain by the Carboniferous Macumber Formation (Windsor Group), in assumed faulted contact with the Triassic Chedabucto Formation.

Based on work carried out as part of this project we have informally subdivided the Horton Group in the study area into the Clam Harbour River, Tracadie Road, Caladonia Mills and Steep Creek formations (Figs. 2 and 3). We agree with White and Barr (1998a, b) and exclude the Glenkeen or Hadley Cove formations from the Horton Group. We have further subdivided the Clam Harbour River and Tracadie Road Formation into members.

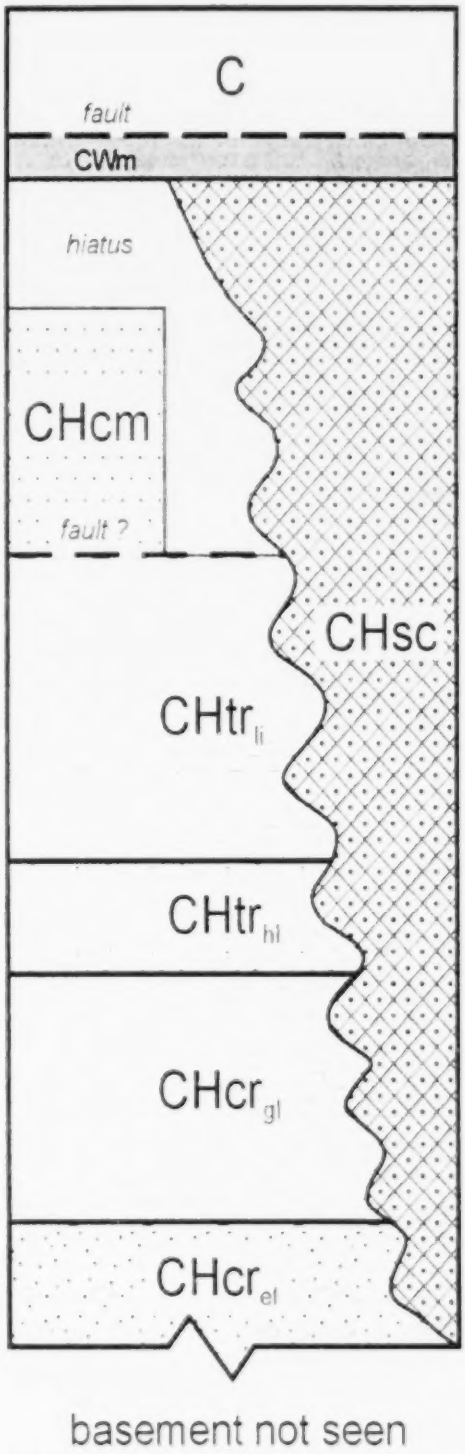

Figure 3. Simplified stratigraphic column for the Lochaber - Mulgrave area (refer to Legend in Fig. 2).

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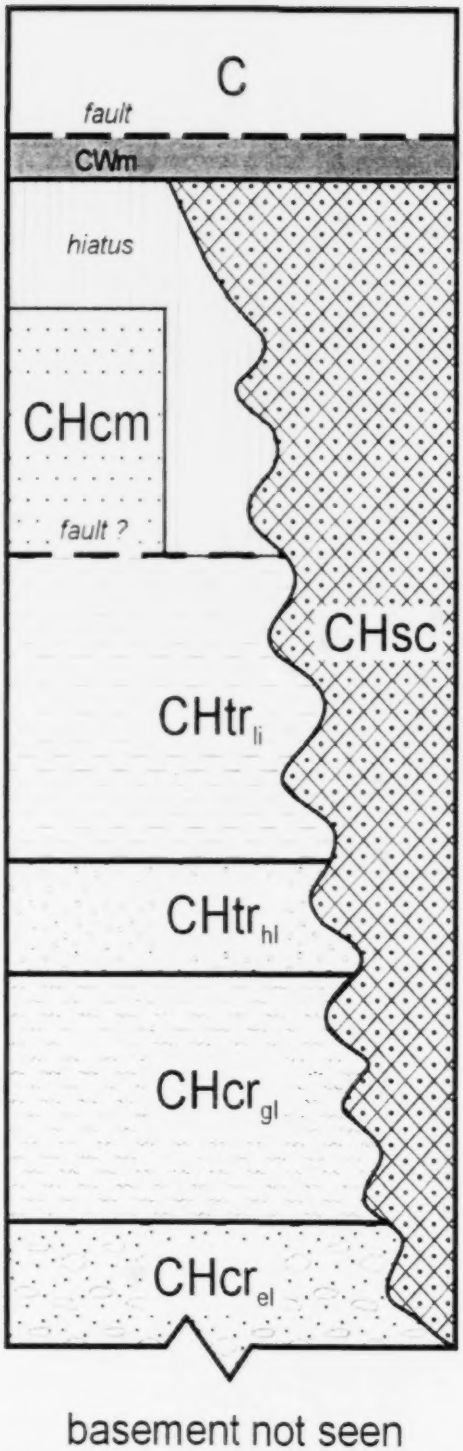

Figure 3. Simplified stratigraphic column for the Lochaber - Mulgrave area (refer to Legend in Fig. 2).

Clam Harbour River Formation

The base of the Clam Harbour River Formation occurs in faulted contact with other stratigraphic units. Therefore, it is possible to provide only a minimum thickness of 1500 m for the formation.

We have subdivided the Clam Harbour River Formation into the Englands Lake and Goose Harbour Lake members (Fig. 3). The Englands Lake Member forms the lower part of the Clam Harbour River Formation and is exposed on the east side of the map area near Englands Lake (Fig. 2). Equivalent strata may occur outside the map area on Isle Madame, but the correlation is tenuous. The Englands Lake Member consists of polymictic conglomerate and fine- to coarse-grained sandstone interbedded with red and green mudrock.

The Englands Lake Member is conformably overlain by the Goose Harbour Lake Member, which constitutes the upper 800 m of the Clam Harbour River Formation (Fig. 3). The Goose Harbour Lake Member consists of green mudrock with local thin (<1 m) fine-grained sandstone interbeds. The mudrock has a well-developed cleavage that makes recognition of bedding and sedimentary structures difficult. Bedding is generally tabular, less than 0.35 m thick, and distinguished on the basis of subtle grain size or colour variation. Beds often appear massive. However, millimetre-scale varve-like laminae or flaser to lenticular fine-grained sandstone laminae occur locally. Centimetre-scale graded bedding is common and usually occurs in fine-grained sandstone that grades upward through siltstone to claystone. Massive sandstone can also grade upward through ripple bedded sandstone to siltstone with lenticular sandstone laminae.

Siderite and dolomite layers up to 5 cm thick and finely disseminated pyrite are locally common within the mudrock. Thin (<0.15 m) beds of pale grey, massive or ripple-bedded, fine-grained sandstone are locally found interbedded with the green mudrock. Rare interbeds of massive medium- to coarse-grained sandstone, 5-10 cm thick, were also noted.

Near the contact with the Tracadie Road Formation the green mudrock of the Goose Harbour Lake Member is locally interbedded with pale red-grey sandstone and red mudrock. The sandstone is fine- or medium-grained and up to 2 m thick. Trough cross-stratification and ripple bedding are the most common bedforms. The red mudrock contains occasional flaser to lenticular sandstone laminae and green mottles.

Redbeds are not always present near the contact between the Tracadie Road Formation and the Goose Harbour Lake Member. In some locations redbeds are absent and the green mudrock of the Goose Harbour Lake Member is interbedded with black shale similar to that found in the Tracacdie Road Formation.

No plant, animal or trace fossils were observed in the Clam Harbour River Formation. We have not submitted samples of the Clam Harbour River Formation for palynological analysis.

Tracadie Road Formation

The Tracadie Road Formation outcrops throughout much of the central map area (Fig. 2). The formation is at least 1350 m thick and is in conformable contact with the Clam Harbour River Formation (Fig. 3). The nature of the contact with the overlying Caladonia Mills Formation is uncertain and is discussed under subsequent headings. We have subdivided the Tracadie Road Formation into the Halfmoon Lake and Lincolnville members.

The Halfmoon Lake Member forms the lower 600 m of the Tracadie Road Formation. Throughout much of the map area the Halfmoon Lake Member consists of a thick (>10 m) succession of pale grey sandstone and polymictic conglomerate, with thin (<3 m) interbeds of grey mudrock and black shale. The conglomerate can be clast- or matrix-supported, with pebble to cobble sized clasts. Individual conglomerate units have a maximum thickness of 6 m. Sandstone units are fine- to coarse-grained, locally appear arkosic, and are poorly sorted. Sandstone and conglomerate units can be planar and trough cross-stratified.

However, systematic vertical changes in grain size and the scale of bedforms were not recognized. The mudrock and black shale interbeds are not common and they often appear to be eroded laterally by coarser sediments.

Locally, black shale and grey mudrock are more common within the Halfmoon Lake Member. Conglomerate and sandstone are still the dominant rock type, although shale and mudrock units can be greater than 10 m thick.

The Halfmoon Lake Member is conformably overlain by the Lincolnville Member (Fig. 3). The Lincolnville Member is approximately 750 m thick and consists of black shale and grey mudrock with subordinate pale grey sandstone. The black shale is locally highly calcareous (e.g. near Mulgrave) and generally appears massive or has local pale grey sandy streaks. The grey mudrock can also be highly calcareous and typically has varve-like or lenticular laminae. Sandstone units are pale grey, fine-grained and 0.05 to 8.0 m thick. Thin (>1 m) sandstone units are commonly ripple bedded, and thicker sandstone units are typically cross-stratified.

The Lincolnville Member can be generally described as comprising three facies assemblages. Thick (10-40 m) shale- and mudrock-dominated successions with rare thin sandstone interbeds are the most common type of facies assemblage. Thinly interbedded sandstone, mudrock and shale successions, consisting of stacked 1-8 m thick coarsening-upward sequences, are increasingly common up section. The least common facies assemblage consists of 4-8 m thick fine- to medium-grained sandstone units that are typically well sorted, arenaceous and cross-stratified.

Plant fossils are rare and usually poorly preserved within the Lincolnville Member. Fossil roots were locally noted within thick sandstone units and near the top of coarsening-upward sequences. Well preserved fossil plant stems identified as late Devonian to Tournasian lepidodendropsis (Calder, personal communication, 2001) were found in association with coarsening-upward sequences on Monastry Brook near Monastary (Fig. 2). Similar fossil plants have been described in the Tracadie Road Formation north of Chedabucto Bay. No other macro-fossils or trace fossils have been recognized within the Tracadie Road Formation.

Utting (2002) recovered palynomorphs from samples of the Linconville member that are comparable to those found in the Horton Bluff Formation at the Horton type section. This supports a Tournasian age for the Lincolnville Member.

Caledonia Mills Formation

The Caledonia Mills Formation is disconformably overlain by the Windsor Group and possibly the Steep Creek Formation (Fig. 2). The contact between the Caledonia Mills Formation and the underlying Tracadie Road Formation is enigmatic. Abrupt changes in bedding attitude commonly occur near the contact between these two formations, although we have not located any exposures of the actual contact.

Substantial changes in the total thickness of the Caledonia Mills Formation often occur very abruptly across a series of northwest-trending faults (e.g. Monastery Fault, see Fig. 2). It is very difficult to explain this thickness variation simply on the basis of lateral change in sediment accumulation. A possible explanation is that faulting and erosion of the Caledonia Mills Formation occurred prior to deposition of the Windsor Group. This could have resulted in less erosion of the Caledonia Mills Formation occurring in down-faulted blocks.

A second possibility is that within the map area the contact between the Tracadie Road and Caledonia Mills formations is actually a south-easterly dipping thrust fault. On average the contact between the Caledonia Mills and the Tracadie Road formation strikes roughly parallel to the South Merland Fault (Fig. 3). Bedding in the Caledonia Mills Formation typically strikes more to the east of this trend. Therefore, if the contact between the two formations is a thrust fault, it would explain the apparent tendency for the Caledonia Mills outcrop pattern to narrow to the northeast.

Subsequent movement along the northwest-trending faults would still be required to explain the abrupt variation in apparent thickness of the Caledonia Mills Formation. The fault contact between the two formations would dip to the southeast, and beds in the Caledonia Mills dip to the northwest. Therefore, normal movement of a block between two faults would produce an apparent narrowing of the Caledonia Mills Formation map pattern. Hence, a minimum thickness of 1500 m is assigned to the Caledonia Mills Formation.

The Caledonia Mills Formation consists of red mudrock with subordinate pale grey to red-grey sandstone and green grey mudrock. Rare occurrences of black shale and polymictic conglomerate have also been observed. Red mudrock with local thin (<1 m) red fine-grained sandstone and green-grey mudrock interbeds form successions up to 50 m thick. The red mudrock locally exhibits green mottling and poorly developed calcrete nodules. The pale grey fine-grained sandstone units are typically 5 to 15 m thick and usually multistoried. Each story is approximately 2 m thick and consists of a trough cross-stratified base overlain by 1-3 m of ripple bedding. The ripple bedding typically consists of linguoid ripples. Intervals 1 to 5 m thick, consisting exclusively of ripple-bedded fine-grained sandstone were also observed.

Polymictic conglomerate occurs in coastal exposures along the Strait of Canso near the base of the Caledonia Mills Formation. At this location the conglomerate appears to almost entirely consist of granitoid clasts from the Cape Porcupine Complex.

Plant fossils are very difficult to locate within the Caledonia Mills Formation. This is particularly true in the southwestern part of the map area. Rare, poorly preserved roots and green reduction zones around possible root traces are the only evidence of fossil plants that were observed. The Caledonia Mills Formation has not been sampled for palynomorphs.

Steep Creek Formation

The Steep Creek Formation occurs south of Cape Porcupine in the northwest part of the map area (Fig. 2). The Steep Creek Formation is approximately 500 m thick and rests unconformably on the Tracadie Road and Clam Harbour River formations (Fig. 3). We assume that the Steep Creek Formation unconformably overlies the Caledonia Mills Formation (Fig. 2). However, the contact relationship between the two formations is unclear. The Macumber Formation directly overlies the Steep Creek Formation with no apparent angular discordance. Based on tentative palynological evidence (Utting, 2002) the contact between the two formations is apparently a disconformity.

The Steep Creek Formation comprises black shale, red, green grey and grey mudrock, pale grey and green-grey, fine- to coarse-grained sandstone and polymictic conglomerate. The black shale units can be 1 to 10 m thick and commonly contain thin (<1 m) interbeds of grey mudrock and pale grey, fine-grained sandstone. Locally, black shale grades upward to green-grey mudrock with faint millimetre-scale dark grey colour banding and thin (<2 cm) carbonate layers. The green-grey mudrock commonly grades up-section into red mudrock with pedogenic carbonate nodules.

Black shale units also form the base of coarsening-upward successions that are 10 to 25 m thick. A typical coarsening upward succession consists of black shale interbedded with grey mudrock and ripple-bedded fine-grained sandstone, overlain by low-angle cross-stratified and ripple-bedded pale grey or green-grey fine-grained sandstone, which grades upward to fine- to medium-grained pale grey fine-grained cross-stratified sandstone. The sandstone is well sorted and arenaceous. Pebble conglomerate units up to 2 m thick were noted near the top of some of the coarsening-upward successions. Convolute bedding is locally common, particularly within thin sandstone beds near the base of coarsening-upward units.

Interbedded sandstone and conglomerate units up to 35 m thick are also common within the Steep Creek Formation. The base of these units typically consists of 1 to 6 m of pale grey, polymictic granule- to pebble-conglomerate with local to

abundant red interformational mudrock clasts. Lithic clasts often appear to be subangular and poorly sorted. Up-section the polymictic conglomerate grades to poorly sorted and somewhat arkosic cross-stratified medium-grained sandstone with local pebbly layers. Ripple bedding is rare and systematic vertical changes of bedforms were not observed. The interbedded sandstone and conglomerate units are often abruptly overlain by black shale and are typically found in erosional contact with red sandstone or mudrock.

A few very poorly preserved plant fossils have been observed within sandstone beds of the Steep Creek Formation. However, the specimens were so degraded identification was not possible. Trace fossils are also very rare and were only observed in one green-grey sandstone unit near Pirates Harbour. Two types of trace fossils were observed in grey mudrock near the middle of a coarsening-upward succession, *Undichna sp.* (sinusoidal trail made by fish) and an unidentified arthropod trackway.

Basin Configuration and Depositional Environments

A detailed discussion of basin configuration and depositional environments is beyond the scope of this report. However, it is possible to make some general observations based on the data presented here.

It is difficult to estimate the size and configuration of the Horton Basin(s) within the study area. Lateral changes in the thickness of various stratigraphic units occur, but it is difficult to determine if this is a result of faulting, folding, erosional unconformities or the original sedimentation patterns. Therefore, sediment thickness does not currently provide a useful guide to basin configuration. Similarly, basin-fill patterns are not well enough understood to clearly define coarsening and fining trends. Locally derived conglomerate clasts (e.g. Cape Porcupine Complex granite clasts in the Caledonia Mills Formation) occur at various stratigraphic levels, indicating some of the sediment was locally derived. However, there are no clearly defined coarsening trends to indicate the proximity or direction of the paleo-basin margins. The Horton Group adjacent to the Guysborough Group Block (Fig. 2) exhibits no obvious lithostratigraphic change, suggesting this was not a paleo-basin boundary.

A variety of fluvial, alluvial and lacustrine deposits appear to constitute the Horton Group within the study area. To date we have undertaken only a preliminary examination of the sedimentology of these deposits. A preliminary discussion of the types of deposits that are interpreted to constitute each stratigraphic unit is provided below.

The sandstone- and conglomerate-dominated Englands Lake Member of the Clam Harbour River Formation is poorly exposed, which makes it difficult to study. Until further work is done we are limited to describing it as consisting of fluvial sandstone, mudrock and conglomerate.

The green mudrock and thin sandstone of the overlying Goose Harbour Lake Member appear to be lacustrine deposits. Supporting evidence for this interpretation includes the occurrence of distinctive varve-like laminae, and the absence of fossil roots, paleosols and fluvial sandstone. Massive sandstone beds that grade upward to lenticular-bedded siltstone appear to be waning flow deposits. Coupled with the common occurrence of normal graded beds, these facies have some broad similarities to lacustrine turbidites.

The occurrence of redbeds and thicker sandstone units at the top of the Clam Harbour River Formation appears to herald the deposition of thick channel sandstone and conglomerate successions at the base of the Tracadie Road Formation (i.e. Halfmoon Lake Member). The redbeds may represent lacustrine shoreline deposits or possibly floodplain deposits that accumulated in interfluve areas between the fluvial channels at the base of the Tracadie Road Formation.

The absence of clear, systematic vertical changes in bedforms, rare occurrence of mudrock interbeds, and the common occurrence of both planar and trough cross-stratification indicate that the thick sandstone and conglomerate units of the Halfmoon Lake Member are probably braided river deposits. Local occurrences of thick grey mudrock

and black shale interbeds may indicate periodic development of lacustrine conditions.

Lacustrine conditions appear to have prevailed during deposition of the Lincolnville Member of the Tracadie Road Formation. Evidence for a predominately lacustrine origin include the generally fine-grained nature of the deposits, excellent preservation of sedimentary structures, and the lack of evidence for subaerial exposure or plaeosol development. Thick black shale and mudrock sequences with thin sandstone interbeds are interpreted as distal lacustrine/pro-delta deposits. Coarsening-upward shale to sandstone successions are interpreted to represent more proximal lacustrine delta-fill deposits. The occurrence of fossil roots at the top of some of the coarsening-upward successions suggests that as lakes were infilled, delta plains formed and were colonized by plants. The 4 to 8 m thick, fine– to medium-grained, cross-stratified sandstone units appear to be distributary channel deposits that may have fairly limited lateral extent. Fossil roots at the top of these deposits indicate that when these channels became infilled and abandoned they formed topographic highs that were favourable for plant growth.

Channel and overbank deposits appear to constitute the Caledonia Mills Formation. The cross-stratified multistoried sandstone units may be channel deposits of high sinuosity rivers. However, further work is required to more fully characterize these deposits. The red colour, close association with channel sandstone, and paleosol development indicate the thick mudrock-dominated units are overbank deposits. However, it is difficult to reconcile the rare occurrence of fossil roots within these strata.

The Steep Creek Formation appears to consist of both lacustrine and fluvial deposits. The coarsening-upward shale to sandstone successions are interpreted as lacustrine delta-fill deposits that are broadly similar to those found in the Linconville Member. Evidence for a lacustrine delta origin includes the excellent preservation of sedimentary structures, the absence of fossil roots, the presence of fish and arthropod trackways, and the gradual upward increase in grain size and scale of bedforms. Upward transitions from black shale through green murock to red mudrock with pedogenic carbonate are interpreted to represent a gradual regression of a lacustrine shoreline. The thick multistoried sandstone units with interbedded conglomerate are interpreted to be braided river deposits. The poorly sorted and immature nature of the sandstone and the angular lithic clasts in the conglomerate suggest rapid deposition under periodic flood conditions, possibly in distal areas of a braidplain.

Economic Geology

As part of the Targeted Geoscience Initiative project, other workers will carry out an evaluation of known mineral occurrences on map area 11F/11. These results will be provided in a future report. For the purposes of this report a few brief comments on resource potential are provided below.

There appears to be very little potential for hydrocrbon exploration in the study area. The thermal alteration index of spores is commonly very high (T.A.I. 4/5; Utting, 2002). This equates to a vitrinite reflectance value of Ro 3.5%, which is beyond the limit of dry gas preservation.

Martin Marietta Limited operates a large aggregate quarry in the Cape Porcupine Complex at Aulds Cove. Aggregate from this operation is supplied to clients throughout the Maritimes and from Texas to New England. No further mapping of the Cape Porcupine Complex was undertaken as part of this study. However, White *et al.* (2001) undertook detailed mapping of the Cape Porcupine Complex and this work provides useful information for future aggregate mining of the Cape Porcupine Complex.

An additional potential source of aggregate, identified in this study, is the highly calcareous black shale of the Linconville Member of the Tracadie Road Formation. We are currently evaluating its potential to act as a carbonate source for cement production.

Known metallic mineral occurrences are predominately galena and sphalerite associated

with carbonate veins (DeMont, personal communication, 2001).

Future Work

During the 2002 field season, measurement and description of a reference or type section will be undertaken for each formation and member of the Horton Group. The contact relationship between the Caledonia Mills and Tracadie Road formations will also be the focus of further study.

Future work will also include comparing the stratigraphy and depositional history of the Horton Group in the study area to Horton Group strata in the St. Marys Graben and southeastern Cape Breton Island.

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Preliminary Bedrock Geology of the Tusket Map Area (NTS 20P/13), Southwestern Nova Scotia

C. E. White and M. S. King[1]

Introduction

Bedrock mapping related to the Southwest Nova Scotia Mapping Project continued through the summer of 2001 on the Tusket (NTS 20P/13) map area (Fig. 1a). This project represents the fourth year of a five-year program by the Nova Scotia Department of Natural Resources aimed at producing a series of 1:50 000 scale geological maps of the Digby-Yarmouth-Shelburne area (Fig. 1b). Details of the mapping program, previous geological investigations and methodology were summarized by White *et al.* (1999), and preliminary results of the first three years (covering parts of NTS map areas 21A/12, 21A/05, 21B/08, 21B01, 21O/16) were presented by White *et al.* (1999, 2000, 2001), Horne and White (2000) and Horne *et al.* (2000).

Field Relations and Map Units

Introduction

Based on previous regional bedrock mapping (Taylor, 1967; Rogers and White, 1984; Rogers, 1985a, b, 1986, 1988; Rogers and Barr, 1988) the rocks in the map area were subdivided into formal units. Additional mapping related to mineral exploration was conducted on parts of the map area by Shell Canada Resources Limited (e.g. Cant *et al.*, 1978) and the Department of Natural Resources (Chatterjee and Keppie, 1981; Ham and MacDonald, 1994). Metamorphic rocks include the Cambrian to Ordovician Meguma Group, consisting of the lower Goldenville Formation and the upper Halifax Formation, and the Silurian White Rock Formation (WRF). These units have been deformed and regionally metamorphosed to varying degrees, generally ranging from sub-greenschist facies (chlorite grade) in the western half of the map area to amphibolite facies (sillimanite grade) in the eastern half. The metamorphic units are intruded by the Late Devonian Barrington Passage and Shelburne plutons, and the Carboniferous Wedgeport Pluton. All these units were recognized during the present study and unit names have been retained (Fig. 2). In addition, a new stratigraphic subdivision of the Goldenville Formation has been recognized, and two new units have been informally assigned member status. The metamorphic units, including the Wedgeport Pluton, are intruded by minor Early Mesozoic mafic dykes and sills (e.g. Pe-Piper and Reynolds, 2000).

Exposure is generally limited due to poor access, low topographic relief and extensive glacial deposits. High-resolution second derivative aeromagnetic data (Fig. 3) were used to assist in the definition of map units.

Goldenville Formation

In the previously mapped areas to the north (Fig. 1a), the Goldenville Formation could not be rigorously subdivided into mappable stratigraphic units, although a narrow magnetite-bearing meta-siltstone unit with abundant trace fossils (High Head member) was traced for several kilometres (White *et al.*, 2001). The Goldenville Formation in the map area has been subdivided into two stratigraphic units based on similarities with units defined in the Goldenville Formation farther to the northeast in Queens and Lunenburg counties (Hope and Woodend, 1986; O'Brien, 1986, 1988; Waldron, 1987, 1992). At this stage of the project the member names New Harbour and Tancook established in these areas are adopted here.

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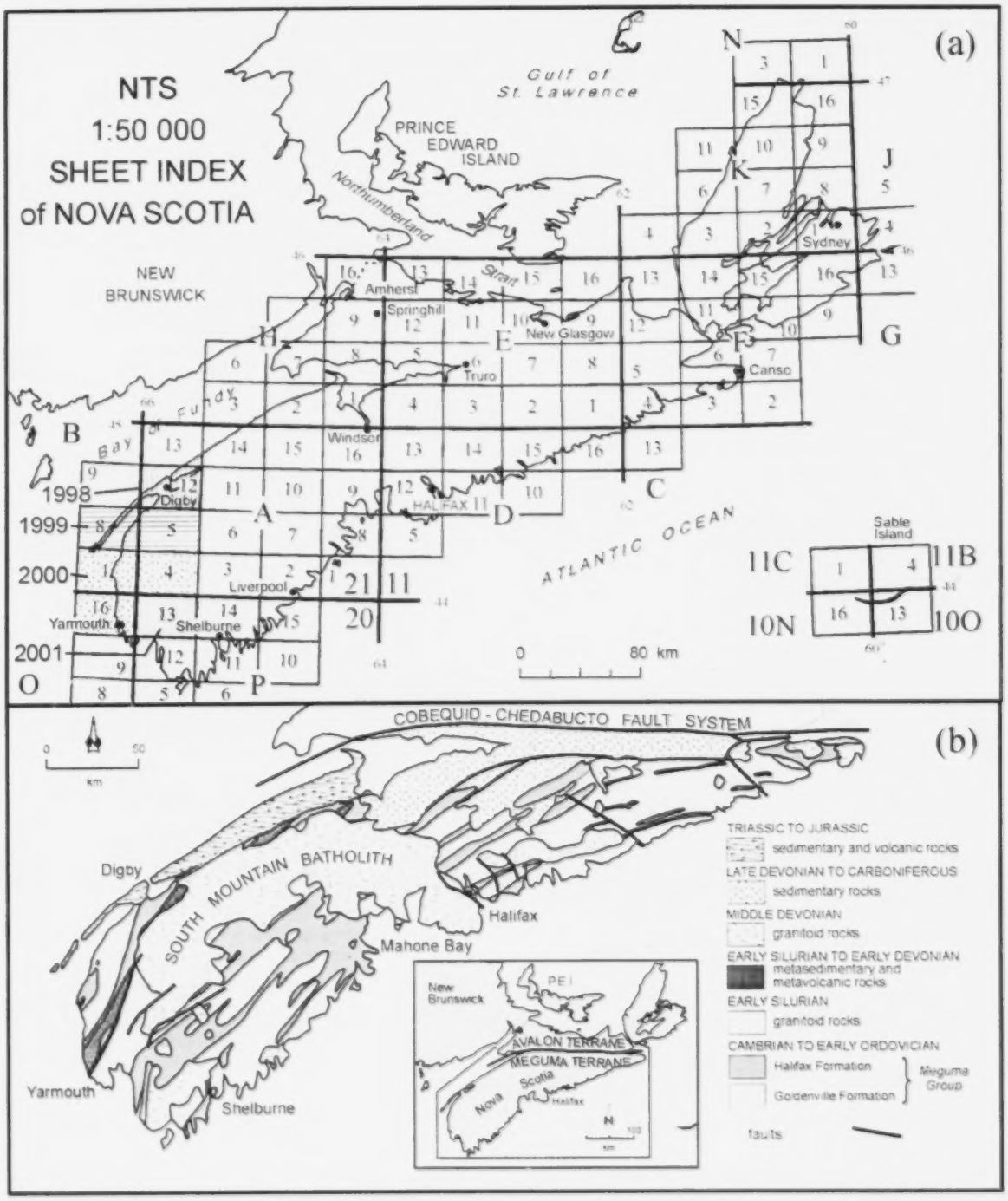


Figure 1. (a) National Topographic System (NTS) index map of Nova Scotia showing locations of mapped areas related to the Southwest Nova Scotia Mapping Project. (b) Simplified geological map of the Meguma Terrane, Nova Scotia.

New Harbour member

The New Harbour member (O'Brien, 1986) occurs in the western half of the map area (Fig. 2). It consists of thick-bedded metasandstone, locally interlayered with cleaved metasiltstone and rare black slate. In general, its appearance is typical of the Goldenville Formation exposed to the north (e.g. White *et al.*, 1998, 2000, 2001; Horne *et al.*, 2000) and may be equivalent. The metasandstone is grey to greenish-grey, thickly bedded and locally contains brown weathered, calc-silicate lenses that are flattened parallel to bedding. In the field the metasandstone displays few sedimentary structures to indicate its mode of deposition, or enable the determination of a stratigraphic top. Sand volcanoes are locally common, which suggests that dewatering may have been responsible for obliterating many of the structures (e.g. O'Brien, 1988). Many of the green-grey metasiltstone beds display parallel laminations where cleavage does not obscure these features. Black slate beds are not well exposed, but where present are well cleaved and pyritiferous, and display a strong positive aeromagnetic response (Fig. 3) which helps define the distribution of the unit. The western margin of the New Harbour member is in faulted contact with rocks typical of the Cunard member of the Halifax Formation. The eastern contact is not exposed, but based on work to the northeast (e.g. Hope and Woodend, 1986; O'Brien, 1986, 1988; Waldron, 1987; 1992) is interpreted to be conformably overlain by the Tancook member. However, in this map area the contact maybe modified by younger shear zones and faults (see Shear Zones and Faults section).

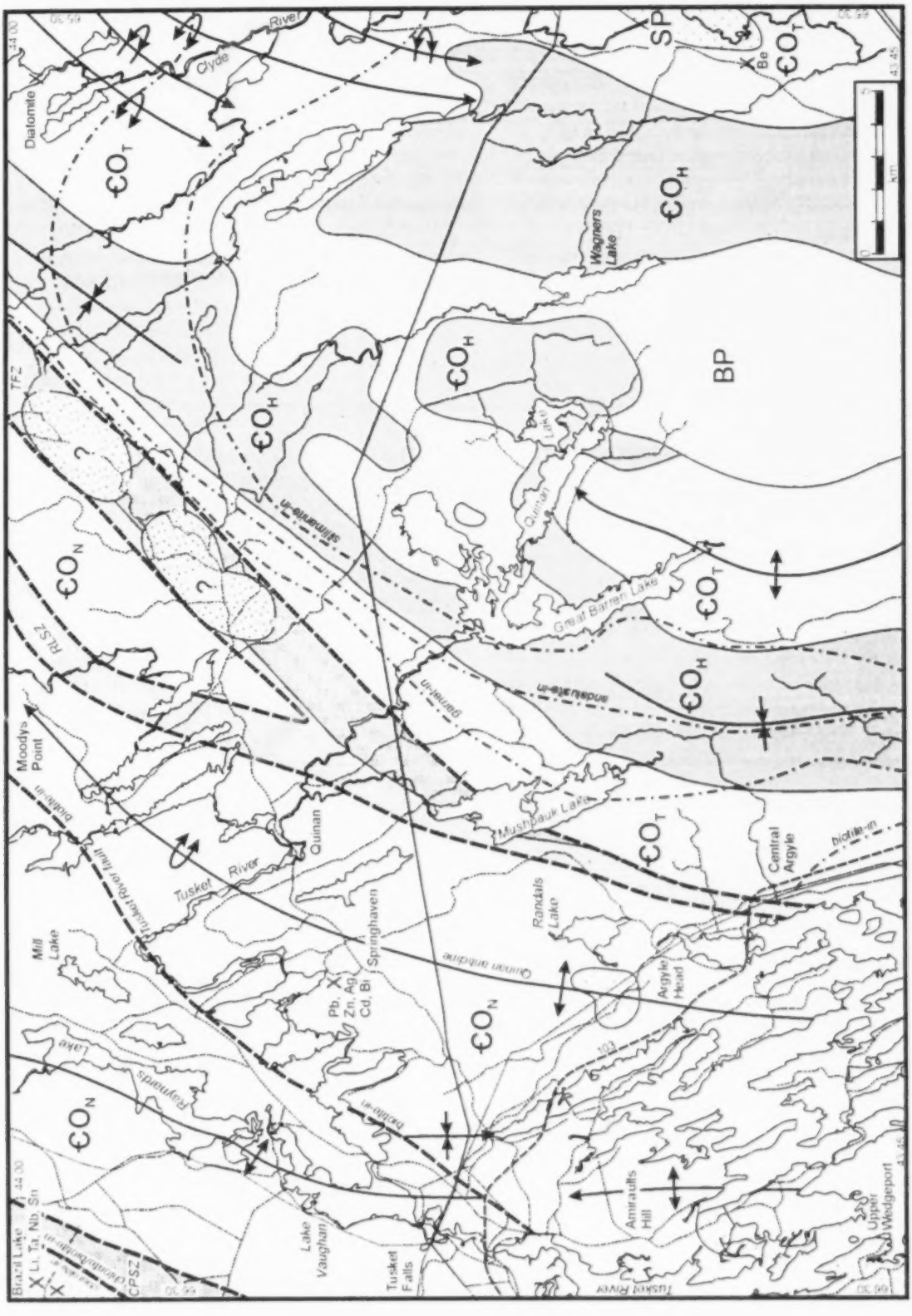
Tancook member

The Tancook member is confined to the eastern half of the map area (Fig. 2). In areas of low metamorphic grade it is typically composed of green, rhythmically laminated, cleaved metasiltstone interlayered with medium-bedded metasandstone. Locally the metasandstone and metasiltstone display cross-stratification and convolute laminations. Calc-silicate nodules are common and flattened parallel to bedding. This package of rocks closely resembles the Tancook member (as defined by Waldron, 1987,1992) which is equivalent to the West Dublin member of the Green Bay Formation (O'Brien, 1986, 1988) or the lower member of the Green Bay Formation in the Port Mouton area (Hope and Woodend, 1986). This member is regionally correlative with the Goldenville-Halifax "transition zone" (e.g. Waldron, 1987,1992) and may be stratigraphically correlative to the Bloomfield member exposed to the north (e.g. White *et al.*, 1998, 2000, 2001; Horne *et al.*, 2000). In the present map area, the more pelitic beds in this member at higher metamorphic grades are composed of andalusite-staurolite schist, garnet-sillimanite schist/granofels and migmatite. The calc-silicate lenses become zoned with various proportions of garnet, amphibole, epidote and calcite.

The andalusite-staurolite schist is light grey and strongly schistose with poikiloblasts of andalusite and staurolite. The andalusite is commonly pink and subidioblastic, with maximum dimensions up to 3 cm in diameter and 15 cm in length. Andalusite is confined to discrete bands that may represent more aluminum-rich beds. Locally the andalusite defines a prominent mineral lineation. Staurolite poikiloblasts are brown, idioblastic, commonly twinned and randonly oriented. The largest staurolite grains are up to 15 mm long. Light grey-green cordierite poikiloblasts up to 4 cm in length are locally present. Subidioblastic pink to red-brown garnet grains, generally about 1-2 mm in diameter, are common.

The red-brown garnet-sillimanite schist and granofels occur adjacent to the northern margins of the Barrington Passage Pluton and contain idioblastic garnet up to 2 cm in diameter, rimmed by 1-2 mm of white fibrolite (sillimanite). The weathered surface commonly exhibits a honey-comb texture where garnet has weathered out, leaving the sillimanite rim.

Migmatitic rocks are characterized by dark grey fine-grained paleosomes with neosomes containing leucocratic medium-grained leucosomes and dark grey melanosomes. The leucosomes have quartzofelspathic compositions, whereas the melanosomes are mainly biotite and sillimanite. Idioblastic red-brown garnet porphyroblasts occur in the melanosomes but are generally absent in the


Clyde River
Dalhousie
Wagners Lake
Great Barrier Lake
Mushabuk Lake
Moody's Point
Tusket River
Quinan
Springhaven
Mill Lake
Raynards Lake
Randals Lake
Central Argyle
Argyle Head
Amirault's Hill
Upper Wedgeport
Tusket Falls
Lake Vaughan
Brazil Lake
Li, Ta, Nb, Sn
Pb, Zn, Ag, Cd, Bi
Be
SP
BP
TFZ
RLSZ
CPSZ
Quinan antiform
Quinan synform
Tusket River fault
Raynards Lake fault
Tusket River fault
Quinan detachment
Tusket River fault
Tusket River fault
Tusket River fault

LEGEND

JURASSIC

SHELBURNE DYKE: basalt

LATE CARBONIFEROUS

WEDGEPORT PLUTON: monzogranite

LATE DEVONIAN

? Plutons of unknown affinity

BP *BARRINGTON PASSAGE PLUTON*: tonalite to quartz diorite

SP *SHELBURNE PLUTON*: monzogranite to granodiorite

SILURIAN

WHITE ROCK FORMATION: amphibolite and staurolite schist

CAMBRIAN TO ORDOVICIAN (MEGUMA GROUP)

HALIFAX FORMATION

(low metamorphic grade)
slate to spotted slate

$\mathcal{E}O_H$ *(high metamorphic grade)*
andalusite-staurolite schist, garnet sillimanite schist/granofels, migmatite

GOLDENVILLE FORMATION

Tancook member?

(low metamorphic grade)
metasandstone, metasiltstone and slate

$\mathcal{E}O_t$ *(high metamorphic grade)*
metasandstone, andalusite-staurolite schist, garnet sillimanite schist/granofels, migmatite

New Harbour member?

$\mathcal{E}O_n$ mainly metasandstone with minor metasiltstone and slate

SYMBOLS

SHEAR ZONES
CPSZ = Chebogue Point Shear Zone
RLSZ = Rushmere Lake Shear Zone
TFZ = Tobeatic Fault Zone

FOLD:
plunging anticline
plunging overturned anticline
plunging syncline
plunging overturned syncline

METAMORPHIC ISOGRADS

MINERAL OCCURRENCE X Pb, Zn

BRITTLE FAULT

GEOLOGICAL CONTACT

MAIN HIGHWAY 103

SECONDARY ROAD

POWER LINE

leucosomes. Xenoblastic cordierite occurs in the melanosomes, neosomes and locally in the leucosomes.

Halifax Formation

In the northwestern part of the map area a thin unit of black to dark grey, very magnetic slate is assigned to the Cunard member (e.g. White *et al.*, 2000, 2001). It is a fault-bounded unit that separates the White Rock Formation to the west from the New Harbour member of the Goldenville Formation to the east. The western contact is marked by an abrupt change in metamorphic mineral assemblages (see Metamorphism section), whereas the eastern contact is marked by brittle deformation in the slate. This zone lies within the Cheboque Point shear zone (e.g. White *et al.*, 2001). In the southern part of the map area, the Halifax Formation consists of rust-brown to grey slate that locally contains abundant pyrite. With an increase in metamorphic grade toward the east and northeast, the slate becomes andalusite-staurolite schist and at the highest grades, garnet-sillimanite schist/granofels and migmatite. These higher metamorphic grade rocks are lithologically identical to those interlayered with metasandstone in the Tancook member (see above) and will not be re-described here. Along the western margin of the Barrington Passage Pluton, migmatitic rocks are poorly developed. Here the Halifax Formation is dominantly garnet-sillimanite schist/granofels. Locally, original sedimentary layering is still evident as defined by 10 to 15 cm wide metasandstone. Along the eastern margin of the pluton extensive areas of migmatite give a chaotic aeromagnetic response (Fig. 3).

In the map areas to the north, the Halifax Formation was subdivided into three stratigraphic units including, from oldest to youngest, the Bloomfield, Acacia Brook/Cunard and Bear River/Sissiboo River members (White *et al.*, 1999, 2000, 2001; Horne *et al.*, 2000). However, in the present map area, the Halifax Formation is difficult to subdivide, except to the northwest, because of the higher grade of metamorphism. The lower grade rocks closely resemble the Acacia Brook member exposed to the north (White *et al.*, 1999); however, the high positive areomagnetic response near the

Figure 3. Grey-scale calculated second derivative aeromagnetic image gridded to a 75 m cell size. Abbreviations: md = mafic dyke, SD = Shelburne Dyke.

inferred base of this unit (Fig. 3) is more characteristic of the Cunard member elsewhere in the Meguma Group (e.g. King, 2000). Future bedrock mapping to the south and northeast in the less metamorphosed equivalent rocks of these units may help in subdividing the formation, but at this time, the Halifax Formation is undivided.

White Rock Formation

The White Rock Formation is exposed only in the northeastern part of the map area (Fig. 2) and was described by White et al. (2001) and MacDonald *et al.* (2002). It consists of biotite-garnet-staurolite schist locally interlayered with massive quartzite and amphibolite. Pegmatite sills and pods are locally present. Due to deformation and amphibolite-facies metamorphism, many primary sedimentary and volcanic features have been obliterated. Geochemistry of mafic volcanic rocks in the White Rock Formation indicates alkalic affinity and a within-plate tectonic setting. The felsic volcanic rocks have some characteristics similar to within-plate A-type granites (MacDonald, 2000; MacDonald *et al.*, 2002).

Intrusive Rocks

Introduction

Granitoid rocks in the map area include the Barrington Passage, Shelburne and Wedgeport plutons (Fig. 2). A study of these units was not a priority of this project, as these units were part of recent detailed studies (Rogers and White, 1984; Rogers, 1985a, b, 1986, 1988; Rogers and Barr, 1988). However, mapping during this study combined with second derivative aeromagnetic data has modified both the shape and distribution of these plutons. In addition, new minor plutons are inferred to exist west and northwest of the Barrington Passage Pluton.

Barrington Passage Pluton

The Barrington Passage Pluton (Taylor, 1967) occurs in the eastern part of the map area (Fig. 2) and was extensively studied by Rogers (1985a,b, 1988) and Rogers and Barr (1988). The pluton consists of grey, medium-grained, strongly foliated biotite tonalite gradational to quartz diorite and granodiorite. The irregular contact and the presence of numerous garnet-sillimanite schist/granofels xenoliths in the northern part of the pluton suggest a more shallow level of erosion compared to the southern part (e.g. Rogers, 1988). Evidence for assimilation of the garnet-sillimanite rocks is obvious in the tonalite adjacent to the xenoliths in the north, where the tonalite locally contains numerous garnet xenocrysts presumably incorporated from the schist. In places, garnet-rich tonalite dykes cut the garnet-sillimanite rocks. Cutting both the tonalite and the country rocks along the margin of the pluton are foliated to unfoliated pegmatite, aplite, equigranular to porphyritic biotite-muscovite granite, and fine-grained tonalite dykes and 'pods'.

The Barrington Passage Pluton has yielded U-Pb zircon and monazite ages of 373 ± 2 and 372 ± 2 Ma, respectively (Keppie and Krogh,1999), interpreted to date the crystallization of the pluton. Titanite from the same location yielded U-Pb ages of ca. 360 and 352 Ma (Currie et al., 1998). In addition, the pluton has yielded several $^{40}Ar/^{39}Ar$ plateau and total gas ages, including ca. 372 Ma for amphibole and ca. 370-285 Ma for biotite and muscovite (Reynolds *et al.*, 1981, 1987; Muecke *et al.* 1988; Dallmeyer and Keppie, 1987, 1988; Keppie and Dallmeyer, 1995).

Geochemistry of the tonalite suggests derivation from an "S-type" magma of intermediate composition in a syn-collisional setting; however, some characteristics are similar to volcanic-arc granites and a subduction zone setting cannot be discounted (Rogers, 1988; Rogers and Barr, 1988).

Shelburne Pluton

Only the extreme western margin of the Shelburne Pluton (Taylor, 1967; Rogers 1986) outcrops in the map area (Fig. 2). However, based on aero-magnetic data (Fig. 3), that part of the pluton forms a northeast-trending elliptical lobe that appears to be separated from the main pluton exposed farther east. Like the Barrington Passage Pluton, the Shelburne Pluton was extensively studied by Rogers (1988) and Rogers and Barr (1988). In the map area the pluton is composed of moderately

foliated, pale grey, medium-grained, bioitite- and muscovite-bearing monzogranite cut by garnet-bearing pegmatite. Dykes of monzogranite and pegmatite are also present in the country rocks near the contact.

The Shelburne Pluton has yielded identical U-Pb zircon and monazite ages of 372 ± 2 Ma (Keppie and Krogh, 1999) interpreted to date crystallization of the pluton. Additional U-Pb monazite dating from the same location yielded a weighted mean U-Pb age of 373 ±1 Ma (Currie *et al.*, 1998). Samples from the Birchtown Diorite, located within the Shelburne Pluton on the map sheet to the south, yielded a U-Pb zircon are of 376 ± 2 Ma (Clarke *et al.*, 1997). Titanite from the same location yielded U-Pb ages of 377 ± 4 Ma and 364 ± 8 Ma (Currie *et al.*, 1998). The pluton has yielded several muscovite and biotite $^{40}Ar/^{39}Ar$ plateau and total gas ages from ca. 371 to 302 Ma (Reynolds *et al.*, 1981, 1987; Dallmeyer and Keppie, 1987, 1988; Keppie and Dallmeyer, 1995). Geochemistry of the granitic rocks suggests a felsic 'S-type' magma formed in a syn-collisional setting (Rogers, 1988; Rogers and Barr, 1988).

Wedgeport Pluton

The Wedgeport Pluton (Taylor, 1967) is poorly exposed in the southwestern part of the map area and its distribution is largely based on areomagnetic data (Fig. 3) and abundant drill core (Cant *et al.*, 1978; Chatterjee and Keppie, 1981; Cullen, 1983; Wolfson, 1983). The pluton is composed of unfoliated, medium-grained, porphyritic to equigranular biotite monzogranite with the southeastern margin of the granite being garnetiferous (Goose Bay granite of Chatterjee and Keppie, 1981). The pluton produced a narrow contact metamorphic zone of spotted hornfels that contains andalusite, cordierite and staurolite. (Chatterjee and Keppie, 1981; Cormier *et al.*, 1988).

The Wedgeport Pluton has yielded a single bulk fraction U-Pb zircon age of 316 ± 5 Ma (Cormier *et al.*, 1988) interpreted to date crystallization of the pluton. Biotite from the granite yielded a $^{40}Ar/^{39}Ar$ biotite plateau age of 258 ± 8 Ma, probably reset by younger mafic intrusions (see below). Geochemistry of the granitic rocks has been done by Wolfson (1983) and Chatterjee *et al.* (1985), mainly in the context of the magmatic and hydrothermal stages of Sn-W-U mineralization in the pluton. More detailed studies of petrogenesis and tectonic setting are planned for future work.

Other Plutons

Elliptical areas that display aeromagnetically low responses appear to truncate linear structures. Two such areas occur to the northwest of the Barrington Passage Pluton (Fig. 3). Because this area has extensive glacial till deposits and no outcrops were located, we interpret these 'lows' to represent unexposed plutonic units. It is unclear if these bodies are related to the Barrington Passage Pluton or the South Mountain Batholith, exposed on the map area to the north. A third areomagnetic low occurs east of Randals Lake (Fig. 3). However, in this area metamorphic grade appears to be higher, and the metasandstone and interlayered metasiltstone outcrops are spotted with large biotite and small cordierite(?) grains. In addition, metasiltstone boulders in the area contain granitic porphyry dykes that suggest that an intrusion maybe responsible for the metamorphism. These granitic porphyry dykes are similar to some rocks in the Wedgeport Pluton. More detailed work is needed in this area to verify the presence of these plutonic units.

Mafic Dykes

Compared to the map areas to the north (e.g. White *et al.*, 1999, 2000, 2001; Horne *et al.*, 2000), pre-Late Devonian mafic dykes and sills were not observed in the Goldenville and Halifax formations in the map area southeast of the Chebogue Point shear zone. However, mafic dykes interpreted to be of Early Mesozoic age, and presumably related to early rifting of the North Atlantic Ocean, occur in the southern part of the map area. The dykes are poorly exposed, but were intersected in several drillholes in the New Harbour member and Wedgeport Pluton in the Upper Wedgeport area (Cant *et al.*, 1978; Cullen, 1983; Wolfson, 1983) and are evident on the basis of their aeromagnetic response (Fig. 3). The dykes in the Upper

Wedgeport area are lamprophyre and alkaline olivine diabase, with well developed chilled margins and showing little alteration or assimilation of the host rock (Cullen, 1983; Wolfson, 1983; Pe-Piper and Reynolds, 2000). The lamprophyre dykes have yielded $^{40}Ar/^{39}Ar$ hornblende ages between 231 ± 3 and 222 ± 3 Ma, whereas the alkaline olivine diabase dykes yielded $^{40}Ar/^{39}Ar$ biotite ages of 209 ± 6 and 203 ± 15 Ma (Pe-Piper and Reynolds, 2000).

The Early Jurassic tholeiitic Shelburne Dyke is poorly exposed but based on aeromagnetic data it is present in the extreme southwestern part of the map area (Fig. 2, 3).

Deformation and Metamorphism

Introduction

The Meguma Group throughout southern Nova Scotia was affected by regional deformation and metamorphism during the Early to Middle Devonian Acadian Orogeny. In the map area, this deformation resulted in regional scale north- to northeast-trending folds with an axial planar cleavage. The regional deformation was accompanied by subgreenschist- to amphibolite-facies metamorphism which increases in metamorphic grade from chlorite zone (Tusket Falls area) to cordierite-migmatite zone near the Barrington Passage Pluton (Taylor and Schiller, 1966; Taylor, 1967; Bourque, 1985; Ross, 1985; Misner, 1986; Raeside and Jamieson, 1992).

Deformation

Previously published maps of the area show that the metamorphic rocks are deformed into regional F_1 folds, with the New Harbour and Tancook members exposed in a series of upright to overturned anticlines in the west (Taylor, 1967) and the Halifax Formation exposed in synclines to the east (Taylor, 1967; Rogers, 1986). In addition, several shear zones have been interpreted to exist within the map area (e.g. Keppie *et al.*, 1985). In the present study, aeromagnetic data combined with outcrop controls helped define the spatial extent of many of the structural features.

Based on axial plane traces, F_1 folds are generally north-trending in most of the map area but gently curve toward the northeast in the north (Figs. 2, 3). In the western part of the map area the New Harbour member is folded into a series of upright, shallow north- and south-plunging anticlines and synclines. However, the Quinan anticline is moderately inclined to the northwest, and plunges gently to the northeast with an overturned northwestern limb. The southern extension of this anticline is generally upright (Fig. 2). Folds in the eastern half of the map area, in the Tancook member and Halifax Formation, are upright except in the northeast where a series of overturned anticlines and synclines verge to the east and plunge to the south and southwest (Fig. 2).

Poles to bedding define a moderately developed girdle distribution with a shallow, north-northeast-plunging fold axis (Fig. 4a) and poles to foliation suggest a steep axial planar foliation that strikes north-northeast (Fig. 4b). The scatter in the data may be due to the curvilinear character of the regional folds. Intersection lineations (L_1), although somewhat scattered as well, have a shallow to moderate north-northeast and south-southwest plunge suggesting doubly plunging folds (Fig. 4c). Many of the steep intersection lineations are from the higher metamorphic grade rocks and likely related to the intrusion of the Barrington Passage Pluton (see below). Although calc-silicate nodules are typically flattened parallel to bedding, many are also elongate parallel to the intersection lineation. Minor F_1 folds are not common in the low metamorphic grade rocks, but are common in the garnet-sillimanite schist. They are upright and plunge gently to steeply northeast and moderately to the south (Fig. 4d).

Mineral lineations are locally evident in andalusite schist but are better developed in the garnet-sillimanite schist. The lineation is defined by elongate andalusite, fibrolite mats, or elongate quartz rods. A mineral lineation is also locally well developed in Barrington Passage Pluton and defined by prismatic plagioclase crystals and quartz rods, similar to those documented in the extension of the pluton to the south (Pignotta and Benn, 1999). These mineral lineations (L_m) have gently or steeply, north- to northeast-plunging orientations (Fig. 4e) and in the field parallel the F_1 fold axes.

Similar data from the southern part of the Barrington Passage Pluton indicated a maximum principle stretch parallel to the magmatic mineral lineation and parallel to the subhorizontal, north-northeast and south-southwest trending regional fold axis (Pignotta and Benn 1999). Although some data from the north are shallow-plunging, a great many are steep, suggesting that near-vertical stretching during the emplacement of the Barrington Passage Pluton may be responsible.

A crenulation cleavage deforms axial planar cleavage related to the regional folds. It is generally subhorizontal with a shallow north-northeast plunging crenulation lineation (Fig. 4f). The significance of these features is unknown at this time.

Shear Zones and Faults

Numerous shear zones have been well documented to the south and north of the map area (Giles, 1985; Smith, 1985; Keppie *et al.*, 1985; Hwang, 1990) and along the northwestern margin of the map area (White *et al.*, 2001). Major zones include the Tobeatic Fault Zone (Giles, 1985), Rushmere Lake shear zone (Smith, 1985), Rossignol shear zone (Keppie *et al.*, 1985) and Chebogue Point shear zone (Culshaw, 1994; Culshaw and Liesa, 1997).

The Tobeatic Fault Zone (Giles, 1985) was defined as a major sinistral fault extending from central mainland Nova Scotia to Yarmouth and including the Rushmere Lake shear zone (Smith, 1985) exposed to the north of the map area. Corey and Horne (1989) restricted the distribution of the Tobeatic Fault Zone to the southeastern margin of the South Mountain Batholith but also considered the Rushmere Lake shear zone as the southwestern extension of the Tobeatic Fault Zone. Keppie *et al.* (1985) divided the Tobeatic Fault Zone into a northern shear zone that continued southwest along the northern contact of the Wedgeport Pluton, and a southern extension that was interpreted to parallel the presently mapped contact between the Halifax Formation and the Tancook member, west of the Barrington Passage Pluton. Keppie *et al.* (1985) considered these shear zones to be steep, parallel to the regional strike, and formed in a dextral regime. The Rossignol shear zone lies between the Barrington Passage Pluton and Shelburne Pluton and, like the Tobeatic Fault Zone, was considered to be a penetrative, steep ductile feature with dextral sense of shear that affected both the metasedimentary rocks and the granitic plutons (e.g. Keppie *et al.*, 1985).

Our mapping has not delineated the Tobeatic, Rushmere Lake or Rossignol shear zones in the map area, largely due to limited outcrop. Although the Rushmere Lake and Tobeatic shear zones were considered along-strike equivalents, aeromagnetic data suggest that they may be two separate, parallel shear zones. The southwest extensions of these shear zones can be traced into the current map area by their magnetic responses, which appear to merge and continue south (Fig. 2). The Tobeatic shear zone also appears to envelop the two aeromagnetic 'lows' interpreted to represent buried plutons. However, further detailed mapping and petrographic work is planed to better define these shear zones in the map area.

The Chebogue Point shear zone forms a wide belt along the southeastern contact between the White Rock and Goldenville formations, incorporating the majority of the Halifax Formation (Fig. 2). The shear zone juxtaposes chlorite-grade rocks of the Halifax Formation and New Harbour member with staurolite-grade metamorphic rocks of the White Rock Formation (Hwang, 1985; Moynihan *et al.*, 2001, 2002). At Chebogue Point, kinematic indicators suggest west-side-up dip-slip motion (Culshaw and Liesa, 1997), whereas Dallmeyer and Keppie (1987) and Keppie and Dallmeyer (1995) argued for dextral shear. This zone is strongly overprinted by younger brittle deformation that locally obliterates earlier deformational textures.

To the south of the map area, recrystallized mica in north-south shear zones that post-date the metamorphic peak (e.g. Hwang, 1990) have yielded $^{40}Ar/^{39}Ar$ dates of 335-320 Ma (Dallmeyer and Keppie, 1987). These ages are similar to those obtained in the Cape St. Marys and Cranberry Point shear zones which yielded ca. 320 Ma muscovite ages (Culshaw and Reynolds, 1997). In addition, shearing in the ca. 316 Ma Wedgeport Pluton suggests that much of the ductile deformation in

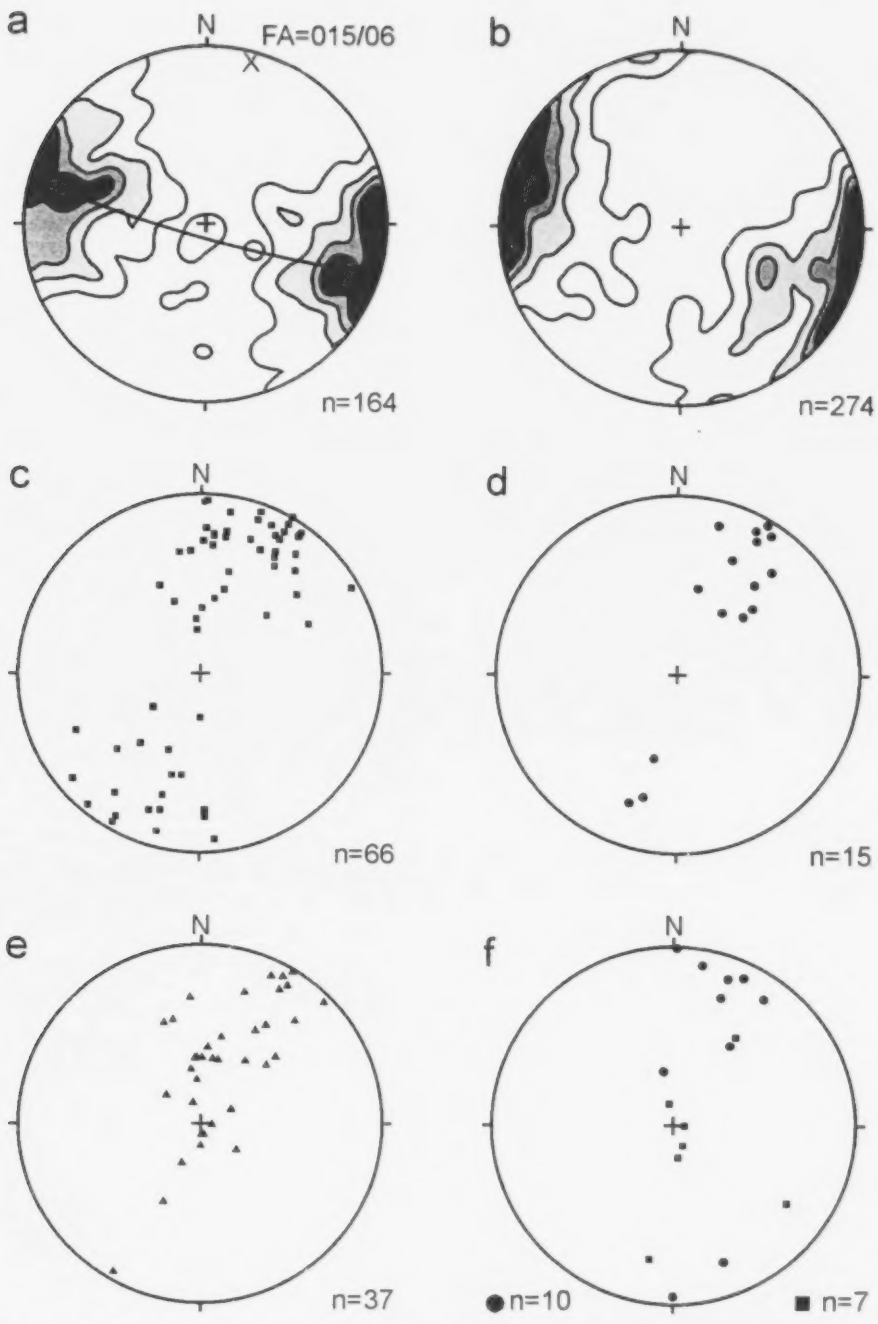


Figure 4. Equal area stereonets of structural data for the map area. (a) contoured poles to bedding. (b) contoured poles to cleavage and schistosity. (c) bedding-cleavage intersection lineations. (d) minor F_1 fold axes. (e) mineral lineations, (f) crenulation cleavage; filled circles represent crenulation lineation and filled squares represent poles to crenulation cleavage. Contours on stereonets at 1, 2, 3, and greater than 4% per 1% area; darkest shading indicates highest contour area.

southwestern Nova Scotia may be Carboniferous or younger in age.

Brittle faults are present throughout the map area. The Cunard member in the northwestern part of the map area in the Chebogue Point shear zone (Fig. 2) is entirely fault-bounded (White *et al.*, 2001). A new fault, informally termed the Tusket River fault, extends from Tusket Falls northeast to Moody Point (Fig. 2) and is recognized on the basis of aeromagnetic data. It approximately coincides with the northern shear zone of the Tobeatic Fault Zone as defined by Keppie *et al.* (1985). Although this feature is not exposed, preliminary petrographic observations indicate that it generally marks the boundary between chlorite- and biotite-bearing rocks of the New Harbour member.

Metamorphism

Several metamorphic zones have been determined in the map area (Bourque, 1985; Ross, 1985; Misner, 1986; Raeside and Jamieson, 1992) which have been modified by the present study (Fig. 2). Rocks assigned to the chlorite zone occur in the western parts of the study area and appear to be confined to the New Harbour member between the Cheboque Point shear zone and the Tusket River fault (Fig. 2). In addition, chlorite zone rocks are noted in the extreme southwestern part of the map area. In this zone chlorite and muscovite define the regional foliation. Locally, spessartine garnet has been noted in the southern chlorite zone (e.g. Raeside and Jamieson, 1992). The biotite zone (Fig. 2) is characterized by the presence of prograde biotite that gives the rock a more spotted appearance. A typical mineral assemblage is biotite + chlorite + muscovite + quartz + albite (e.g. Ross, 1985). Garnet zone rocks are similar to those in the biotite zone except that they contain tiny porphyroblasts of garnet. A typical mineral assemblage is garnet + biotite + muscovite + quartz ± chlorite (Ross, 1985; Misner, 1986). Rocks in the chlorite, biotite and garnet zones typically retain their original sedimentary textures but their mineral assemblage is metamorphic.

The staurolite zone (Fig. 2) is recognized only in the White Rock Formation. The pelitic metasedimentary rocks consist of staurolite + garnet + biotite + muscovite + quartz + plagioclase ± chlorite and display complex shear-related textural features (Moynihan *et al.*, 2001, 2002). In the mafic volcanic rocks actinolite is replaced by hornblende, and plagioclase by oligoclase or andesine (cf. MacDonald, 2000; MacDonald *et al.*, 2002).

The andalusite zone (Fig. 2) is marked by a prominent coarse-grained schistosity, defined by aligned biotite and muscovite, and most of the original textures are obliterated. In addition to andalusite, staurolite and cordierite are locally abundant. This locally gives rise to the relatively rare mineral assemblage of muscovite + cordierite + staurolite + and biotite (e.g. Pattison, 1999). This zone is in the southern and northeastern parts of the map area (Ross, 1985; Misner, 1986). The sillimanite zone (Fig. 2) is generally parallel to the margin of the Barrington Passage Pluton and extends to incorporate most of the Shelburne Pluton farther to the east (White, 1984; Misner, 1986; Raeside and Jamieson, 1992). In the map area this zone can be subdivided into two distinct subzones defined on the basis of texture and mineral assemblages. To the north and east rocks in the sillimanite zone appear to be similar to those in the andalusite zone but contain microscopic sillimanite and fibrolite (Misner, 1985; Rogers, 1988). As grade increases, a dramatic change in texture and mineralogy occurs in the schist. Andalusite, staurolite and cordierite disappear and a more granofelsic texture is developed in the schist. In the granofels and schist the garnet is up to several centimetres in diameter, rimmed by sillimanite, and set in a fine-grained matrix of biotite, muscovite and quartz (Rogers, 1988; Raeside and Jamieson, 1992). Garnet-sillimanite granofels is confined to the area around the northern margin of the Barrington Passage Pluton (Fig. 2).

In comparison to mapping by earlier workers (e.g. Bourque, 1985; Ross, 1985; Misner, 1986; Raeside and Jamieson, 1992), this study shows that the migmatitic aureole around the Barrington Passage Pluton is much more limited in extent. Although migmatitic rocks locally occur in the garnet-sillimanite granofels/schist next to the pluton, the main area of migmatite is confined to

the eastern margin of the Barrington Passage Pluton (Fig. 2), where it displays a chaotic aeromagnetic signature (Fig. 3). Both anatectic and injection migmatites are present. Anatectic migmatite is developed in pelitic rocks and is commonly stromatic or opthalmitic with minor folded and nebulitic varieties (Bourque, 1985). Leucosome consists of quartz + feldspar + mica and rarely cordierite, and is granodiorite in composition, whereas both the melanosome and mesosome contain garnet + sillimanite + biotite + cordierite (Bourque, 1985; Raeside and Jamieson, 1992). Migmatitic lithologies are not developed around the Shelburne Pluton.

Taylor (1967) speculated that the sillimanite-cordierite gneiss (migmatite in this study) was related to contact metamorphism by the Barrington Passage Pluton, but concluded that the regional metamorphic grade for the area was at least as high as the P-T conditions accompanying the emplacement of the granitic pluton. Bourque (1985) concluded that the combined effects of regional amphibolite facies metamorphism and contact metamorphism related to the Barrington Passage Pluton resulted in migmatization. The presence of xenocrystic garnet in tonalite from the granofels suggests that intrusion of the Barrington Passage Pluton accompanied or closely followed the peak of metamorphism.

In addition to the Randals Lake contact metamorphism, the only clear evidence of contact metamorphism is associated with the Wedgeport Pluton (e.g. Taylor and Schiller, 1966). The pluton produced a narrow, 400 m contact metamorphic zone of spotted hornfels containing andalusite and cordierite superimposed on biotite zone assemblages (Cullen, 1983). Although Chatterjee and Keppie (1981) and Cormier *et al.* (1988) reported the existence of staurolite in the contact zone, its presence has not been confirmed.

The precise age of metamorphism is difficult to determine. A detailed $^{40}Ar/^{39}Ar$ study on single grain muscovite and whole-rock samples from the Meguma Group in the Digby area indicated that regional greenschist facies metamorphism associated with the Acadian Orogeny occurred ca. 400 Ma (Muir, 2000). This age is similar to $^{40}Ar/^{39}Ar$ ages reported elsewhere in the Meguma Group (405-390 Ma, Muecke *et al.* 1988; 395-388 Ma, Hicks *et al.*, 1999). Published $^{40}Ar/^{39}Ar$ data from higher than greenschist facies metamorphic rocks in the Meguma Group in the map area, as well as to the south and east of the map area, yielded muscovite and biotite total gas and plateau ages of ca 356-287 Ma and ca. 347-274 Ma, respectively (Dallmeyer and Keppie, 1987, 1988; Muecke *et al.* 1988; Keppie and Dallmeyer, 1995).

A structural and magnetic fabric study of the Barrington Passage Pluton demostrated that the internal fabrics in the pluton parallel those in the country rocks, interpreted to indicate that the pluton was emplaced and deformed during the Acadian Orogeny (Pignotta and Benn, 1999). Based on field relations that indicate that the pluton accompanied or closely followed the peak of metamorphism, and the rapid cooling of the pluton based on age data, it is likely that the ca. 373 Ma age for the Barrington Passage Pluton also dates the time of high-grade metamorphism in the map area.

The $^{40}Ar/^{39}Ar$ muscovite and biotite ages appear to systematically decrease to the south (Dallmeyer and Keppie, 1987, 1988; Muecke *et al.* 1988; Keppie and Dallmeyer, 1995). These younger ages suggest a more complex tectonic history for the area than previously thought (e.g.. Taylor 1967; Rogers, 1988), and may be related to a younger regional metamorphism or plutonism (e.g Keppie and Dallmeyer, 1995), or to deformation related to shear zone development (e.g. Hwang, 1990; Culshaw and Reynolds, 1997).

Economic Geology

The most significant mineral deposit in south-western Nova Scotia, the greisen-hosted East Kemptville Sn-Zn-Cu-Ag deposit in the South Mountain Batholith (e.g. Kontak, 1990), is located less than 10 km north of the map area. As a result of tin exploration in the late 1970s and early 1980s, significant deposits of silica and kaolinite were discovered north of the map area and are currently under development by Black Bull Resources (Keating, 2001; Kontak, 2001). Although the silica

and kaolinite are considered to occur in the Tobeatic Fault Zone (e.g. Keating, 2001), they actually occur in the Rushmere Lake shear zone of Smith (1985). The Tobeatic Fault Zone, a parallel shear zone to the south, locally contains significant Pb-Zn-Ba ± Au mineralization (Corey and Horne, 1989; O'Reilly, 1995). Taken together, these shear zones represent part of a laterally extensive silica-kaolin-base metal and precious metal environment (e.g. Kontak, 2001) that may extend well into the current map area.

A smaller, shear-related granite-hosted deposit, north of the map area at Kempt Snare Lake, includes greisenized leucogranite-leucomonzogranite that hosts quartz veins containing W-Pb-Zn-As-Cu-Ag (Soehl *et al.*, 1989). Although mineralized quartz veins were not observed in outcrop in the map area, the hydrothermal graphite that is associated with this deposit extends southward into the map area, suggesting that this deposit may be larger than previously interpreted. To the south, mineralization associated with the Wedgeport Pluton is shear related. Intense shearing produced graphite schist with complex fracture-filling Sn-Cu-Zn-Bi-Ag-W in greisenized biotite granite (e.g. Chatterjee *et al.*, 1985).

Pegmatitic rocks are locally common. Those in the White Rock Formation at Brazil Lake are Li-Ta-Nb-Sn-bearing (e.g. MacDonald *et al.*, 1992) and the ones associated with the Shelburne Pluton are locally Be-bearing. Boulders of metasandstone in the Springhaven area (Fig. 2) contain quartz veins mineralized with galena, sphalerite and pyrrhotite (Nova Scotia Department of Natural Resources Mineral Occurrence Database - Occurrence Number P13-008).

Conclusions

A major result of the mapping during the summer of 2001 is the demonstration that stratigraphy in the Goldenville and Halifax formations does not correlate with the map units defined to the north (c.f. White *et al.*, 1999, 2000, 2001; Horne *et al.*, 2000). The stratigraphy is more similar to that defined farther northeast in the Meguma Group in Queens and Lunenburg counties (Hope and Woodend, 1986; O'Brien, 1986, 1988; Waldron, 1987; 1992). In addition, the lack of mafic dykes and sills is also noted. The change occurs across the Chebogue Point shear zone, which juxtaposes biotite- and chlorite-zone rocks of the Meguma Group with staurolite-zone rocks of the White Rock Formation, suggesting that this structure is a major feature.

Regional folds in the south have a northerly trend and plunge gently to the north and south. Folds in the north trend northeast and plunge gently northeast and southwest. All folds have well developed axial planar cleavage.

Peak amphibolite facies regional metamorphism appears to have coincided with the intrusion of the Barrington Passage Pluton ca. 373 Ma. It is considerably younger than the ca. 400 Ma greenschist facies regional metamorphism in the Meguma Group.

Many of the shear zones in the map area are known to be directly associated with mineral deposits. Many have not been fully evaluated and hence may provide excellent targets for future exploration (e.g. O'Reilly, 1995).

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The Minimum Model of Glaciation in Maritime Canada: Three Strikes You're Out[1]

R. R. Stea and R. J. Mott[2]

The minimum model of late Wisconsinan glaciation in Maritime Canada evolved from the recognition of autonomous local glaciers into a concept of thin, Late Wisconsinan ice restricted to lowland terrestrial areas, ending up just offshore of the present-day land areas at the glacial maximum. The minimum model was based on three lines of evidence: radiocarbon dates on total organic carbon (TOC) from the offshore glaciomarine sequence and terrestrial lakes and a few marine shell dates, the absence of raised shorelines in the region and the lack of glacial indicators in highland areas (nunataks). The 0 "isobase" in the Gulf of St. Lawrence was considered as a proxy for the Late Wisconsinan ice margin.

Geological mapping on land and offshore since the 1980's has added a wealth of data to apply to this problem especially in the chronology of ice retreat. Offshore, a marine shell radiocarbon chronology has replaced the TOC age dates. Dating of glaciomarine deposits on continental shelf of Nova Scotia has moved the Late Wisconsinan ice limit from just offshore to the continental shelf edge. Highland areas, formerly thought to be nunataks, were found to have an erosional and depositional record from Late Wisconsinan glaciers. The chronology of ice retreat on land is now based on a reliable wood radiocarbon chronology from nearly one hundred sites including lake basins and late-glacial buried organic sites. The new data has produced a deglaciation chronology several thousand years younger than predicted by the minimum model. The construction of the Sable Island gas pipeline across Nova Scotia has provided confirming evidence of a significant re-advance of glaciers in the Gulf of St. Lawrence region as recently as 10.5 ka.

Proponents of the former maximum ice model envisioned a Hudson's Bay centred ice sheet, but the field evidence in Maritime Canada for local glaciation is overwhelming. In essence the emerging new model is one of large, dynamic Appalachian ice caps, with emphasis on powerful ice streams in the Bay of Fundy and Laurentian Channel draining ice divides over the Magdalen Shelf and Nova Scotia. The significant buildup of glacier ice during the aborted Younger Dryas glaciation, lends credence to the Denton and Hughes marine shelf glacierization model, and suggests that the region is very responsive to climate change.

[1]Presented at the Canadian Geophysical Union Annual Meeting, Ottawa, Ontario, May 17, 2001.
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Evidence of the Younger Dryas Advance of a Shelf-based Gulf of St. Lawrence Glacier: An Analogue for Ice Sheet Inception in Maritime Canada?[1]

R. R. Stea and R. J. Mott[2]

In the summer of 1999, the Maritimes and Northeast Pipeline Company excavated a 3 m deep trench across northern Nova Scotia to host the Sable Island gas pipeline. The "great ditch" of Nova Scotia exposed a continuous transect of surficial deposits along a 237 km corridor. A late-glacial paleosol with preserved A horizon (peat and wood) was found buried under 2-10 m of surface till over a wide area of the pipeline route. Ten new sites were sampled and submitted for palynological analysis and radiocarbon dating. The A horizon peaty layer throughout the region is only a few cm thick, and consists mainly of herbaceous plant material with few large wood fragments. It is relatively flat and dips under the trench while the trench follows the gently undulating, fluted glacial topography. Fabric analysis in the reddish surface till, indicated a strong trend parallel to regional glacial lineations. Samples of large pieces of wood from two sites yielded radiocarbon ages of 10.9 ka (GSC-6435) and 10.8 ka (GSC-6419).

Previous to these finds only two localities were known to reveal till overlying peat, so the extent of Younger Dryas glaciers could not be clearly established. The regional till sheet in northern Nova Scotia that overlies the paleosol can be traced to ice-marginal glacio-lacustrine deposits near the Cobequid Highlands to the south, and ice-dammed glacio-lacustrine sediments along the east coast of Cape Breton Island. Glacial flow lines indicated by fabric, fluting and ice marginal deposits imply a YD ice cap centred on the wide continental shelf area of the southern Gulf of St. Lawrence. This marine shelf area was also a centre of outflow during the Escuminac Phase at the Late-Wisconsinan maximum.

Glacierization of Maritime Canada during the Younger Dryas proceeded simultaneously in the uplands and offshore shelf areas by concomitant upland snowfield and lowland aufeis accretion with small remaining outliers of Late Wisconsinan ice acting as "seeds" for incipient glaciers. Ice-advance glacial lakes that developed during the Early Wisconsinan in Maritime Canada suggest the development of similar lowland-based ice masses, before the onset of regional glaciation. The Younger Dryas in Maritime Canada in essence, represents an aborted glaciation. Please view our website for photos and a description of the trench discoveries http://www.gov.ns.ca/natr/meb/field/ditch.htm#ditch

[1]Presented at the 'Glacial Inceptions' Conference, Ire Sweden, June 20-25, 2001.
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Hidden Cretaceous Basins in Nova Scotia[1]

R. R. Stea and S. E. Pullan[2]

Early Cretaceous unconsolidated quartz sand and kaolinitic clay deposits in the lowlands of Nova Scotia are preserved in narrow half-grabens obscured by glacial drift. The Chaswood Formation sediments can be subdivided into three members; upper and lower members dominated by cyclical sand-mud facies of fluvial origin and the middle member with lignitic clay of lacustrine origin. Ferruginous oxisols are common in the fine-grained facies of the upper and lower members. Seismic data indicate that Chaswood Formation strata in the Elmsvale Basin are deformed into steeply dipping faults and fault-related folds (Rutherford Road Fault Zone). An Aptian-Albian age for this tectonic event is inferred from synsedimentary deformation and from the angular unconformity spanning the Late Cretaceous and Tertiary that truncates the Chaswood Formation. Exhumation of a thick cover of Mesozoic sediment (1-2 km) is needed to account for the preservation of Chaswood Formation outliers after ~80 Ma of erosion. The half-grabens which host the Chaswood Formation were formed in the Mesozoic and were antecedent to the present day structurally-controlled lowlands.

[1]Presented at the Canadian Institute of Mining, Metallurgy and Petroleum conference, Halifax, Nova Scotia, October 2001.

[2]Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario, Canada K1A 0E8.

Stratigraphy and Structure of the Horton Group in the Lochaber-Mulgrave Area, Nova Scotia[1]

P. J. Ténière[2], S. M. Barr[2] and C. E. White

A detailed stratigraphic and structural study has been undertaken of sedimentary rocks in the Lochaber-Mulgrave area of northern mainland Nova Scotia. The sedimentary sequence in this area is bounded on the north by the Glenroy Fault and on the south by the Roman Valley Fault, and has been tentatively assigned to the Early Carboniferous Horton Group. It has been divided into three units (from oldest to youngest): (1) Clam Harbour River Formation, (2) Tracadie Road Formation, and (3) Caledonia Mills Formation. The Clam Harbour River Formation contains polymictic conglomerate, light grey to maroon quartz arenite and siltstone, and minor inter-bedded black laminated siltstone, and is interpreted to have been deposited in an alluvial fan-fluvial environment. The overlying(?) lacustrine Tracadie Road Formation consists of grey to black laminated siltstone interbedded with minor quartz arenite and pebble conglomerate. The overlying(?) Caledonia Mills Formation consists of red to greenish-grey, massive to well laminated, siltstone and slate interbedded with minor pebble conglomerate, and is interpreted to have been deposited in a fluvial-lacustrine environment. Based on lithological similarities, the Clam Harbour River, Tracadie Road, and Caledonia Mills formations closely resemble the Creignish, Strathlorne, and Ainslie formations, respectively, of the Horton Group in western Cape Breton Island. However, the stratigraphic sequence appears opposite to that of similar rocks assigned to the Horton Group in the St. Marys Basin. In addition, the Caledonia Mills Formation closely resembles red siltstone exposed west of Lochaber that, based on fossils, has been assigned to the Silurian Arisaig Group.

In comparison to the Horton Group in other areas, the rocks in the Lochaber-Mulgrave area are highly deformed. The western part of the area has open to tight, upright to overturned, northeast- and northwest-trending folds with well-developed axial planar cleavage. The eastern part of the area has tight to close, upright, north-south-trending folds with moderately developed axial planar cleavage. The folded axial plane traces and the scattered cleavage orientations indicate that the area has undergone polyphase deformation and is much more structurally complex than previously thought. Possible complications in Horton Group stratigraphy in the Lochaber-Mulgrave area and its structural complexity may be related to interaction between the Avalon and Meguma terranes during their juxtaposition along the Cobequid-Chedabucto fault system.

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[1] *In:* Atlantic Geoscience Society Colloquium, Program and Abstracts, Moncton, New Brunswick, Feb. 9-10, 2001, p. 32.

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Tectonic Setting of Silurian Magmatism in Nova Scotia and New Brunswick[1]

C. E. White and S. M. Barr[2]

Over the past 15 years, various models for the evolution of the northern Appalachian orogen have suggested that Silurian volcanic and sedimentary units in southern New Brunswick, southern Nova Scotia, and the Antigonish and Cape Breton Highlands of northern Nova Scotia represent a Silurian overstep sequence. Although recent geochronological work has confirmed that these units are of similar early Silurian age (ca. 440 Ma - 430 Ma), mapping and petrochemical studies show that they have different petrochemical characteristics, and do not constitute an overstep sequence.

The Kingston terrane of southern New Brunswick consists of mainly felsic tuffaceous rocks intruded by comagmatic high-level granitic rocks. Both have yielded U-Pb (zircon) ages of ca. 438-435 Ma. Their chemical compositions indicate calc-alkalic affinity and emplacement in a continental margin volcanic arc. These rocks are similar in age, petrologic features, and inferred tectonic setting to volcanic and granitic rocks of the central Aspy terrane in Cape Breton Island, and direct correlation between these now widely separated units is proposed here. They are interpreted to represent a Silurian ocean-closure event between Late Proterozoic-Early Paleozoic peri-Gondwanan terranes. U-Pb dating has shown that volcanic rocks in the White Rock Formation of the Meguma terrane in southern Nova Scotia are of similar Silurian age, but they are a bimodal alkalic basalt-rhyolite suite formed in a within-plate continental extensional setting, and differ chemically from the arc-related Kingston-Aspy volcanic-granitic suites. Silurian volcanic and fossiliferous sedimentary sequences in the Arisaig Group of the Antigonish Highlands are located in the Avalon terrane. Although published descriptions of their petrochemical features suggest that they formed in a continental extensional setting like that of the White Rock Formation, some chemical characteristics are distinct from those of the White Rock Formation, and the two units show little similarity in lithology.

Hence, we suggest that it is not valid to use these widespread Silurian units to infer that the various outboard terranes of the northern Applachian orogen were amalgamated by the Silurian.

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Geology of the Cape Porcupine Complex, Guysborough County, Nova Scotia[1]

C. E. White, S. M. Barr[2], J. W. F.Ketchum[3] and M. Ethier[2]

Varied igneous and metamorphic rocks termed the Cape Porcupine Complex form a prominent hill adjacent to the Canso Causeway. These rocks are situated in a strategic position in the configuration of tectonostratigraphic terranes in the northern Appalachian orogen. Hence this study was undertaken to describe the rock types that form Cape Porcupine, determine their age, and compare them to other "basement" rocks in northern mainland Nova Scotia and adjacent parts of Cape Breton Island.

A fault-bounded metasiltstone unit occupies the central area of the complex. The metasiltstone is typically well foliated with a strong north-trending subhorizontal lineation. A fault-bounded metavolcanic unit forms part of the eastern part of the complex, and consists dominantly of grey crystal to crystal-lithic rhyolitic tuff with phenocrysts of quartz, anorthoclase, and/or plagioclase. Like the metasedimentary unit, it is strongly foliated with a shallow, north-plunging lineation defined by stretched quartz crystals and lithic clasts. Granitoid rocks occur in both the western and eastern parts of the complex. In the west they include bodies of leucodiorite to tonalite, monzogranite to alkali-feldspar granite, and alkali-quartz syenite. In the east the granitoid rocks are dominantly alkali-feldspar granite with minor monzogranite. In addition, the easternmost granitic rocks locally display mylonitic fabric parallel to that in the metasedimentary and metavolcanic units. The Cape Porcupine Complex is intruded by several generations of variably altered mafic dykes. The complex is in faulted contact on its northern and western margins and unconformably overlain on its southern margin by Carboniferous sedimentary rocks of the Clam Harbour River Formation of the Horton Group.

The granitoid units in the Cape Porcupine Complex are Late Neoproterozoic, based on a U-Pb (zircon) age of 610±3 Ma from a syenogranite sample, and hence are similar in age to some granitoid units in southeastern Cape Breton Island and to the Georgeville Pluton in the Antigonish Highlands. However, analysed samples from Cape Porcupine are chemically distinct from the Georgeville Pluton and appear more similar to the felsic components of ca. 620 Ma calc-alkaline plutons of the Mira terrane. The ages of the associated metasedimentary and metavolcanic units are uncertain. The mylonitic units in the Cape Porcupine Complex provide direct evidence for the existence of the Canso Fault and indicate that it is a major pre-Carboniferous, north-south trending feature, and not parallel to the present-day Strait of Canso.

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New Insights to the Geology of the Southwestern Meguma Terrane, Nova Scotia[1]

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A detailed mapping project in the Meguma terrane, from Digby to Shelburne, was initiated in 1998 by the Nova Scotia Department of Natural Resources to produce a series of updated, 1:50,000 scale geological maps of the area.

The oldest units in the map area are the Cambrian to Ordovician Goldenville and Halifax formations. The Goldenville Formation consists mainly of grey metasandstone interlayered with minor metasiltstone, slate and conglomerate. Trace fossils are common in one regionally extensive metasiltstone layer. The overlying Halifax Formation has been divided into three members; Bloomfield, Acacia Brook-Cunard, Bear River-Sissaboo River. These units consist of varying amounts of black to grey and green to maroon slate with minor metasiltstone and metasandstone. Early Tremadocian graptolites have been recovered from of the Bear River member. $^{40}Ar/^{39}Ar$ detrital muscovite ages yield a provenance age of ca. 550 to 600 Ma for the Goldenville and Halifax formations.

The White Rock Formation in the Digby area disconformably overlies the Halifax Formation and consists of grey slate, metasiltstone, and a distinct (<30 m thick) quartzite layer. Late Silurian fossils have been collected near the top of the formation. Detrital $^{40}Ar/^{39}Ar$ muscovite ages indicate a ca. 500 Ma source area. In the Yarmouth area, this formation is in faulted contact with the Halifax Formation and is composed of metavolcanic and metasedimentary rocks, and intruded(?) by the granitic ca. 439 Ma Brenton Pluton. Geochemistry of mafic volcanic rocks indicate an alkalic affinity and a within-plate tectonic setting. The felsic volcanic and granitic rocks have some characteristics similar to within-plate A-type granites. A felsic volcanic unit yielded a U-Pb age of ca. 438 Ma.

Conformably overlying the White Rock Formation in the Digby area is the Early Devonian Torbrook Formation. It consists of grey, locally fossiliferous metasiltstone, slate, metasandstone, marble, and rare ironstone.

Numerous mafic sills intrude all above units and, along with the stratigraphic units, were deformed during the Devonian Acadian Orogeny into regional NE- to NNE-trending, moderately plunging folds with axial planar cleavage. Metamorphism was at greenschist facies; however, in the southwest, metamorphism reached amphibolite facies and was accompanied by ductile deformation. The ca. 370 Ma South Mountain Batholith and related plutons produced andalusite- and cordierite-bearing contact metamorphic aureoles that overprint regional fabrics. $^{40}Ar/^{39}Ar$ data suggest that the ca. 400 Ma Acadian Orogeny occurred immediately after deposition of the Torbrook Formation. A locally occurring intense post-Acadian crenulation fabric reflects regional deformation postulated to be related to Carboniferous aged shear zones.

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Appendix 1
Mining Industry Activity in Nova Scotia, 2000

Mining Industry Exploration, Development, Capital and Repair Expenditures

Investment by the mining industry in Nova Scotia is monitored by means of annual surveys of all mining companies having operations or activity in the province. Aggregate producers are not included in this survey. The surveys are carried out by the Nova Scotia Department of Natural Resources (DNR) jointly with Natural Resources Canada (Minerals and Metals Sector - Minerals and Mining Statistics Division), and Statistics Canada (Investment and Capital Stock Division). The Mineral Management Division of DNR actively participates in the Annual Survey of Canadian Mineral Exploration Expenditures and the Annual Survey on Exploration, Development, Capital and Repair Expenditures.

Preliminary figures indicate exploration expenditures in 2000 were $2.96 million, down somewhat from 1999 (Table 1.1), as was diamond-drilling. Capital expenditures at existing mines dropped significantly in 2000 from 1999, while repair and maintenance expenditures decreased only slightly.

Mining Leases

There was one new Mining Lease issued in the province during the year. In August, Dunlop Mining Corporation Limited was issued a new Mining Lease for its barite property at Walton, Hants County.

A Mining Lease renewal was issued to Scotia Limestone Limited for its limestone property at Kelly Cove, Victoria County.

Table 1.1. Mining industry expenditures in 1999 and 2000.

	1999	2000[1]
Mineral Exploration Expenditures (field plus overhead)[2]	$3,632,000	$2,964,575
Exploration diamond-drilling[2]	14 000 m	8 500 m
Exploration drilling - other[1]	3 000 m	N/A
Mine Complex Development Expenditures (field plus overhead)	$4,881,000	$4,250,345
Capital and Repair Expenditures at Mining Establishments		
Capital Expenditures	$51,455,000	$43,823,619
Repair and Maintenance Expenditures	$23,271,000	$21,024,157

[1]preliminary
[2]includes deposit appraisal

Mining Permits

The department issued two Mining Permits during the year. Georgia-Pacific Canada Inc. was issued a Mining Permit for its gypsum property at Melford, Inverness County, and Cape Crushing Company Limited was issued a Mining Permit for the extraction of coal at its expanded surface mining property at Alder Point, Cape Breton County.

Production Information from Mines, Quarries and Other Operations

In 2000, the estimated total value of Nova Scotia's mineral production, including secondary mineral processing, totaled $315 million (Fig. 1.1), a drop of 22% from the previous year. This decrease was a result of the depletion of crude petroleum production at Cohasset-Panuke in 1999 and a $27 million drop in the value of coal production following the 1999 closure of the Phalen Mine. It should be noted that the value of offshore natural gas production is not included in these figures. Excluding petroleum, the total value of Nova Scotia's mineral production was down 8% from 1999's figure of $342 million. The decrease was mostly due to lower production of coal. Employment in Nova Scotia's mineral industry totalled 2,147 persons (Fig. 1.2), a 26% decrease from the previous year (Fig. 1.3). The drop in employment is primarily a result of the loss of crude petroleum production and workforce reductions by the Cape Breton Development Corporation.

Nova Scotia's gypsum production in 2000 was 7.3 million tonnes shipped. This represents an 8% decrease from 1999's record gypsum production. Gypsum is supplied mainly to wallboard plants along the U.S. Eastern Seaboard. Nova Scotia is Canada's largest gypsum producer, accounting for more than 80% of the country's total production.

Nova Scotia salt production in 2000 increased approximately 8% from 1999, to 912,000 tonnes in 2000.

Coal sales dropped approximately 26% in 2000 to 1.2 million tonnes from 1.6 million tonnes in 1999. This was primarily a result of the loss of the production from the Cape Breton Development Corporation's Phalen Colliery, which closed in 1999. As well, surface coal production decreased by 60 000 tonnes.

Cement sales were consistent with 1999 levels, though production tonnage decreased. Overall, sales of aggregate products (crushed stone, sand and gravel) were unchanged in 2000 from the year before. The value of crushed stone production increased by 6%, while sand and gravel production dropped by 22%. Peat moss production rose 26%

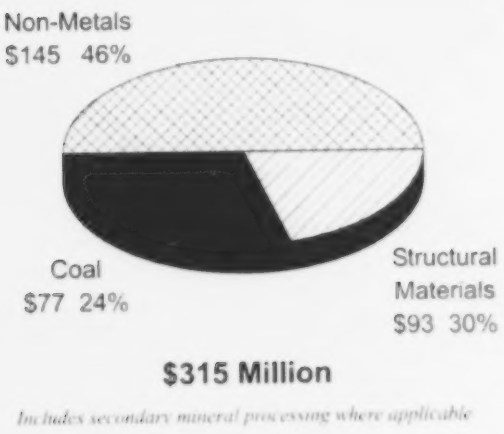


Figure 1.1. Value of mineral production, in millions of dollars and per cent, by commodity group.

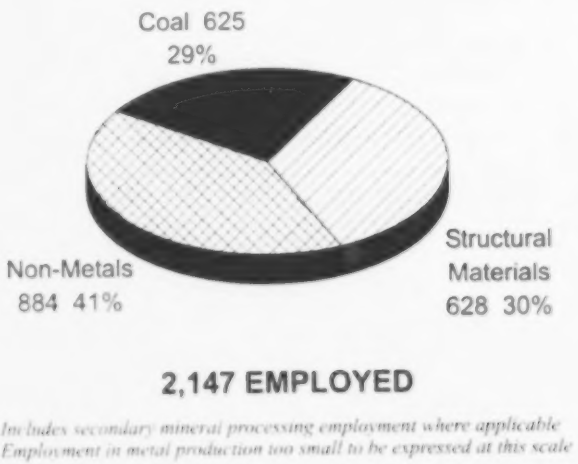
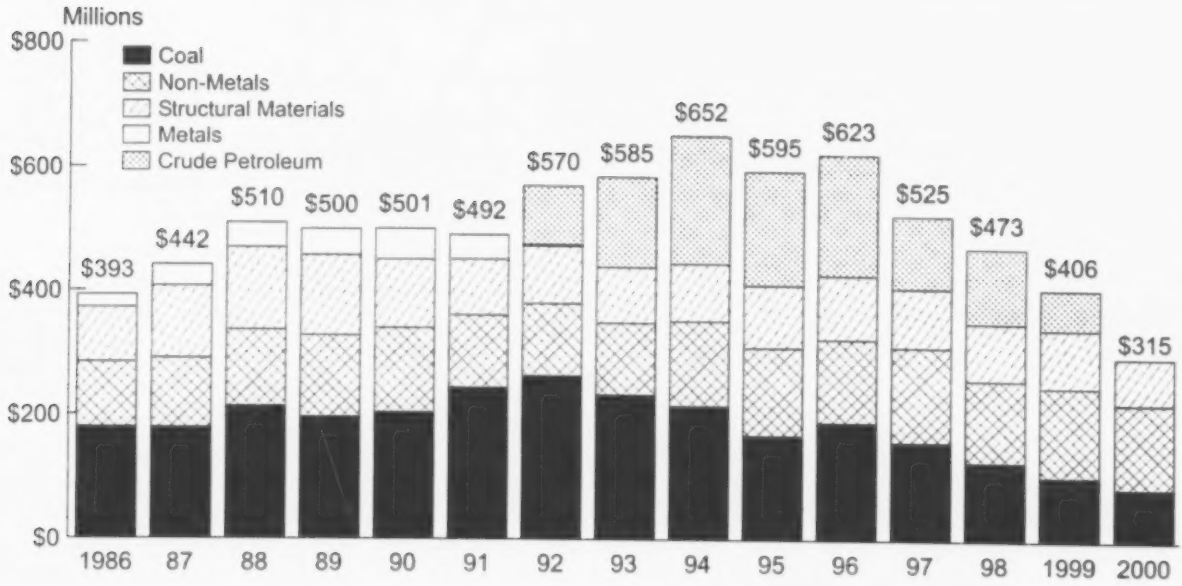


Figure 1.2. Employment, in numbers of persons and per cent, by mineral commodity group.



Includes secondary mineral processing where applicable

Figure 1.3. Historical trend of the value of mineral production in Nova Scotia, 1986-2000.

in 2000 over 1999. Clay products production was similar to 1999 levels.

In prior years, the value of petroleum production has been included in the overall value of Nova Scotia's mineral production, and is reported in the 1999 figures for completeness. However, there was no production of crude oil in 2000 and the production of offshore natural gas is not included in this appendix. The appendix covers the non-petroleum sectors of the mineral industry (Table 1.2), providing a description of each mine site. Tables 1.3 to 1.6 provide more detailed information on the production of different commodities. Site locations are shown on the accompanying maps, Figures 1.4 and 1.5. Production data are for the calendar year 1 January 2000 to 31 December 2000.

Metal Mines and Gold Mines

Metal Mines

There were no producing metal mines in the province in 2000.

Gold Mines

DUFFERIN RESOURCES INCORPORATED

Manager: W. Coles (Envirogold Technologies Inc.)
Address: Dufferin Resources Incorporated
P. O. Box 2020
Windsor, N. S. B0N 2T0
Production: n/a (approximately 4 000 tonnes of ore stockpiled for milling in 2001)
Employees: 10

The Dufferin Mine at Port Dufferin was dewatered and mine development resumed in the latter half of 2000. Approximately 4 000 tonnes of ore were mined and stockpiled for the re-opening of the mill in 2001. Envirogold Technologies Inc. operated the mine under arrangement with the Mining Lease holder, Dufferin Resources Incorporated.

Coal Mining Operations

During 2000, there was one underground coal

Table 1.2. Summary of Nova Scotia mineral production, 1999 and 2000.

DESCRIPTION	1999 VALUE ($ thousands[1])	1999 EMPLOYMENT*	2000 VALUE ($ thousands[1])	2000 EMPLOYMENT*
METALS				
Gold	24		0	
Total metals	24	N/A[2]	0	10
INDUSTRIAL MINERALS				
(Non-Metals)				
Anhydrite	2,018		2,202	
Barite	**1,410		140	
Gypsum	83,204		76,340	
Limestone[3] and Dolomite	3,619		5,444	
Peat	**2,035		2,559	
Salt	**49,891		54,048	
Silica	2,400		4,143	
Total Non-Metals	144,577	893	144,876	884
(Structural Materials)				
Dimension Stone	302		300	
Cement	**37,306		36,750	
Clay Products	**6,000		6,000	
Crushed Stone	39,544		41,795	
Sand & Gravel	10,615		8,236	
Total Structural Materials	93,767	697	93,081	628
Total Industrial Minerals	238,747		237,957	1,522
FUELS				
Coal	103,430	1,010	76,880	625
Petroleum - Crude	64,000	300	N/A	N/A
Total Fuels	167,430	1,310	76,880	625
TOTAL MINERAL PRODUCTION	406,202	2,900	314,837	2,147
CHANGE FROM PREVIOUS YEAR	-14%	-21%	-22%	-26%
TOTAL EXCLUDING PETROLEUM	342,202	2,600	314,837	2,147
CHANGE FROM PREVIOUS YEAR	-3%	-22%	-8%	-17%

[1] Estimated from Department of Natural Resources sources
[2] Operator ceased production in January 1999
[3] Does not include the value of limestone quarried for cement production
* Average number of persons during production period
** Processed or manufactured value
Note: Production represents shipments; numbers may not add to totals due to rounding

Table 1.3. Coal production for the calendar year 2000.

COMPANY	MINE NAME	LOCATION	PRODUCTION			
			TONS	TONNES	TOTAL NUMBER EMPLOYED[1]	APPROX. VALUE($)[2]
UNDERGROUND MINING						
Cape Breton Development Corp. (CBDC)	Prince Mine	Point Aconi, Cape Breton County	934,678	847 925	500	
Total (underground)			934,678	847 925	500	
SURFACE MINING						
Brogan Mining Company Limited	Little Pond Mine	Alder Point, Cape Breton County	60,627	55 000	25	
Cape Crushing Company Limited	Marion Pond Mine	Alder Point, Cape Breton County	12,770	11 585	6	
Evans Coal Mines Limited	St. Rose Mine	St. Rose, Inverness County	44,159	40 060	20	
Hill Reclamation Limited		Springhill, Cumberland County	11,105	10 074	17	
Pioneer Coal Limited	Stellarton Mine	Stellarton, Pictou County	204,622	185 630	35	
Thorburn Mining Limited	Thorburn and Coalburn Mines	Thorburn and Coalburn, Pictou County	41,811	37 930	23	
Total (surface)			375,094	340 279	125	
TOTAL FOR ALL COAL PRODUCERS			1,309,772	1 188 204	625	$76,589,000

[1]personnel employed in clerical, supervisory, etc. positions as well as mining personnel
[2]estimated from Nova Scotia Department of Natural Resources sources
NOTE: Production represents shipments, numbers may not add to totals due to rounding

Table 1.4. Industrial minerals production by the calendar year 2000

COMPANY	LOCATION	PRODUCTION		TOTAL NUMBER EMPLOYED	APPROXIMATE VALUE ($)
		TONS	TONNES		
GYPSUM					
Fundy Gypsum Company	Milton, Cheverie and Avonsworth Road, Hants County	1,912,522	1,735,009	261	
Georgia-Pacific Canada, Inc.	Nappan, Cumberland County	1,730,196	1,569,606	117	
Little Narrows Gypsum Company	Little Narrows, Victoria County	1,169,101	1,060,590	102	
National Gypsum (Canada) Limited	Port Hilford, Hants County	3,202,456	2,905,217	190	
Total (gypsum)		8,014,275	7,270,422	670	[illegible]
ANHYDRITE					
Fundy Gypsum Company	Avonsworth Road, Hants County	98,369	89,238	included in gypsum	
Little Narrows Gypsum Company	Little Narrows, Victoria County	98,004	88,907	included in gypsum	
Total (anhydrite)		196,373	178,145		[illegible]
SALT					
The Canadian Salt Company Limited	Pugwash, Cumberland County	923,196	837,509	147	
Sifto Canada Inc.	Pugwash, Cumberland County	82,112	74,491	43	
Total (salt)		1,005,308	912,000	240	[illegible]
LIMESTONE AND DOLOMITE					
Lafarge Canada Inc.	Brookfield, Colchester County	817,356	741,492	70	
Mosher Limestone Company Limited	Upper Musquodoboit, Halifax County	28,877	26,197	30	
Nova Scotia Power Incorporated	Little Narrows, Cape Breton County	110,970	100,670	40	
Ridge Brokers Limited	Southside Hebron, Annapolis County	20,451	18,553	11	
Scotia Limestone Limited	Scotia Cove, Victoria County	3,307	3,000	12	
Total (limestone and dolomite)		980,961	889,912	163	[illegible]
BARITE					
E-Z-EM Canada Inc.	Brookfield, Colchester County	543	493	31	
Total (barite)		543	493	31	[illegible]

Table 1.4. Continued

COMPANY	LOCATION	PRODUCTION TONS	PRODUCTION TONNES	TOTAL NUMBER EMPLOYED	APPROXIMATE VALUE ($000)
CLAY AND SHALE					
Shaw Brick (a member of the Shaw Group Limited)	Antrim, Pictou County; New Glasgow, Pictou County	30,000	27,216	see clay products Table 1.5	[illegible]
Total (clay and shale)		30,000	27,216	see clay products Table 1.5	[illegible]
SILICA SAND					
Lafarge Canada Inc.	[illegible], Cumberland County	110	100	included with limestone	
Shaw Resources (a member of the Shaw Group Limited)	[illegible], Pictou County	92,975	84,345	[illegible]	
Total (silica sand)		93,085	84,445	[illegible]	[illegible]
DIMENSION STONE					
Heritage Memorials Ltd.[2]	[illegible], Annapolis County (granite); [illegible], Pictou County	1,654	1,500	[illegible]	
Wallace Quarries Ltd.	[illegible], Pictou County (sandstone); [illegible], Cumberland County	278	252	included in aggregate	
Total (dimension stone)		1,932	1,752	[illegible]	[illegible]
PEAT MOSS					
Annapolis Valley Peat Moss Company	[illegible], Kings County	4,900	4,445	[illegible]	
Clare Organic Products Ltd.[2]	[illegible], Shelburne, Digby County	5,000	4,536	[illegible]	
McDonald Peat Moss Limited[2]	[illegible], Pictou County	7,293	6,616	[illegible]	
Total (peat moss)		17,193	15,597	[illegible]	[illegible]
AGGREGATES					
Crushed Stone	[illegible]	8,376,473	7,599,002	[illegible]	[illegible]
Sand and Gravel	[illegible]	2,136,260	1,937,981	[illegible]	[illegible]
Total (aggregates)		10,512,733	9,536,983	[illegible]	[illegible]
TOTAL FOR UNDERNOTED MINERALS		20,852,403	18,916,965	[illegible]	[illegible]

[1]total employees, mining, production, clerical, management, etc.
[2]estimate from Nova Scotia Department of Natural Resources [illegible]
[3]processed or manufactured value.
[4]does not include the value of Lafarge Canada Inc. production, [illegible] included in the higher manufactured value (cement)
[5]value included in the higher manufactured value [illegible]
[6]excluding secondary mineral manufacturing (Table 1.5).
Note: production represents shipments, numbers may not add due to rounding.

Table 4.5: Secondary mineral manufacturing for the calendar year 2000

COMPANY	LOCATION	PRODUCTION		TOTAL NUMBER EMPLOYED[1]	APPROX. $VALUE[2]
		tonnes	tonnes		
CLAY PRODUCTS					
Shaw Brick (a member of the Shaw Group Limited)	Lower Hants County	30,000	27,210	30	6,000,000
PORTLAND CEMENT					
Lafarge Canada Inc.	Brookfield, Colchester County	275,913	250,304	68	36,750,000
TOTAL FOR SECONDARY MINERAL MANUFACTURING				113	42,750,000

[1]total number of employees including office, clerical, supervisory, mining and production
[2]estimated from Nova Scotia Department of Natural Resources sources
NOTE: Production represents shipments; numbers may not add to totals due to rounding

mine, six surface coal mines, and a coal recovery project operating in the province. Production information for the mines is summarized in Table 1.3. The summaries below give brief details of the underground and surface coal mines operating in Nova Scotia.

Underground Coal Mine

CAPE BRETON DEVELOPMENT CORPORATION

Manager: P. MacNeil, Mine Manager, Prince Colliery
Address: P. O. Box 2500, Sydney, N. S. B1P 6K9

Hub Coal
Production: 914,678 tons (847,925 tonnes)
Employees: 500

The Cape Breton Development Corporation is a federal Crown Corporation that operates the underground Prince Mine at Point Aconi, Cape Breton County. The mine began underground production from the Hub Seam in 1975, initially using room and pillar methods. Mechanized retreat longwall operations began in 1980. The corporation's coal production is supplied to Nova Scotia Power Inc. (NSPI).

During 2000, coal was mined from the No. 1 North longwall panel and development work was carried out for the 2 North and 10 East longwall panels.

Surface Coal Mines

EVANS COAL MINES LIMITED

Manager: B. MacDonnell
Address: P. O. Box 1324, Antigonish, N. S. B2G 2L7
Production: 64,150 tons (60 060 tonnes) of coal
Employees: 24

Evans Coal Mines Limited began surface coal mining operations at St. Rose, Inverness County, in 1991, following the closure of the underground mine in 1992. Coal is extracted from the No. 5 Seam crown pillar and from the pillars left by the underground operation. During the year, mining continued in a block of coal north of the previously backfilled pit. Overburden and waste rock are removed by blasting and ripping by bulldozers. Material is loaded and hauled using hydraulic excavators and off road haul trucks.

Production from the Evans Mine is trucked to Pioneer Coal's facility in Stellarton for blending with other coals, and subsequently supplied to NSPI.

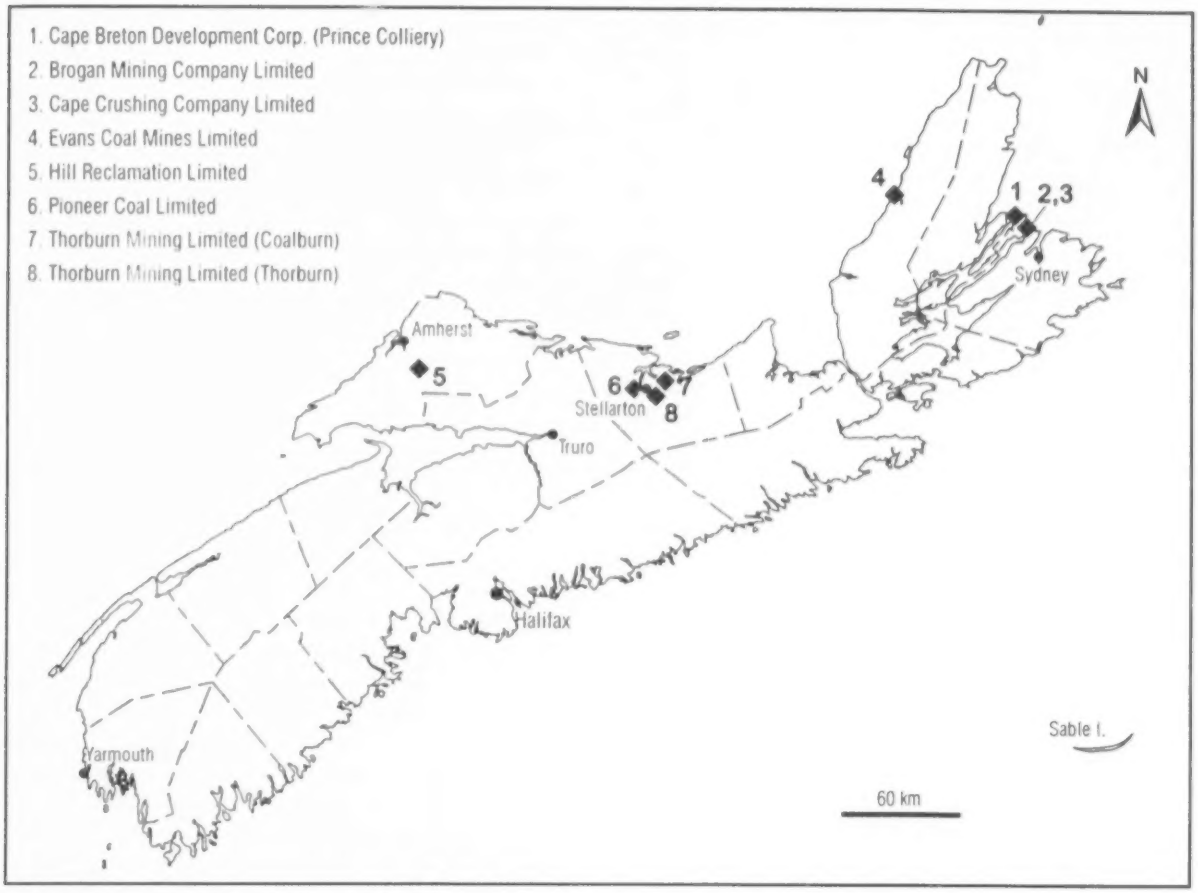


Figure 1.4. Location of coal mines in Nova Scotia, 2000.

PIONEER COAL LIMITED

Manager: C. Chisholm
Address: P. O. Box 1328
Antigonish, N. S. B2G 2L7
Production: 204,622 tons (185 630 tonnes) of coal
Employees: 35

Pioneer Coal began mining coal from the Foord Seam at the Stellarton mine site, Pictou County, in 1996. The Foord Seam is approximately 40 feet thick. Mechanical equipment is used to break the coal and overlying rock and the material is excavated using hydraulic excavators, conveyors and off-road haul trucks. Mining proceeded to the east during 2000. The company conducted mining operations at the site from January through June and November through December. Operations were affected by a labour dispute between June and early November.

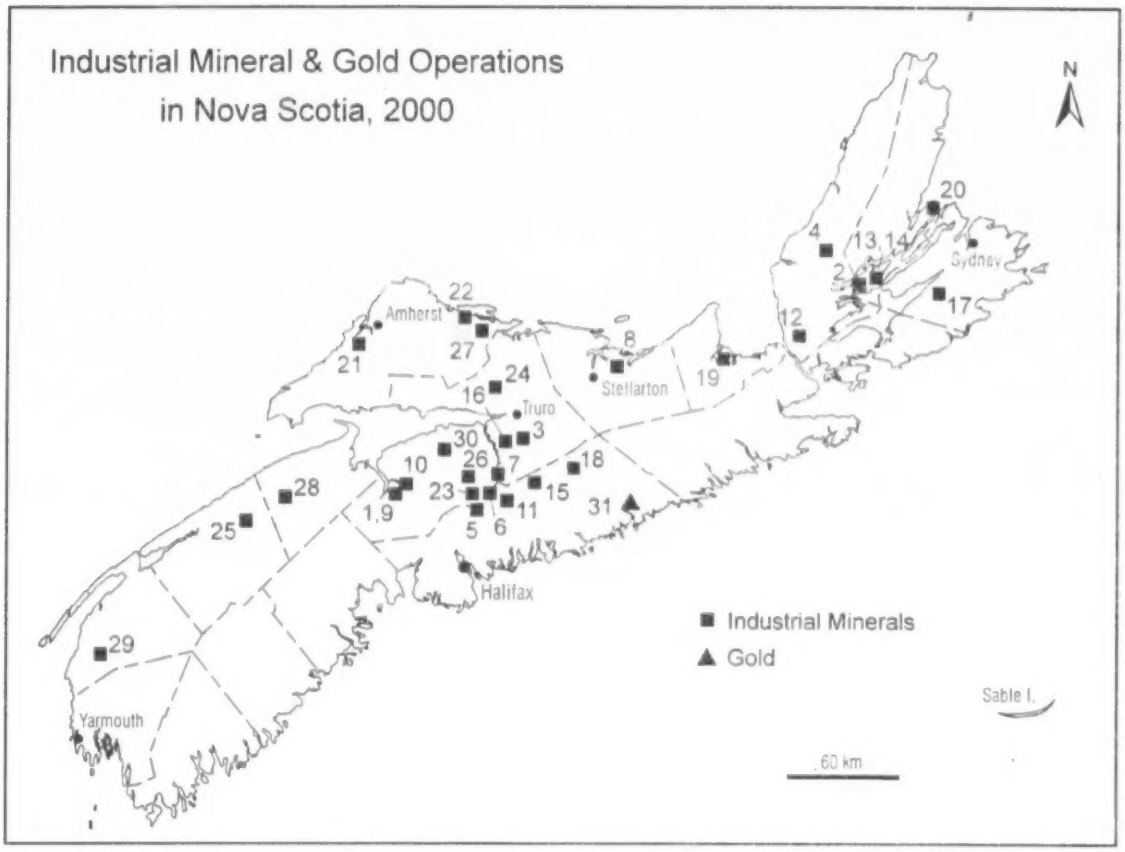
The coal mined from the Stellarton operation is blended on-site with coal trucked from the Evans Coal Mine, the Thorburn Mine and the Coalburn Mine, before being shipped to Nova Scotia Power generating stations.

THORBURN MINING LIMITED

Manager: C. Chisholm
Address: P. O. Box 1328
Antigonish, N. S. B2G 2L7

Thorburn Mine

Production: 6,614 tons (6 000 tonnes) of coal
Employees: Included with the Coalburn Mine workforce



Anhydrite
1. Fundy Gypsum Co.
2. Little Narrows Gypsum Co.

Barite
3. E-Z-EM Canada Inc.
4. Lynx Minerals Inc.

Clay and Shale
5-8. Shaw Brick, a member of the Shaw Group Limited

Gypsum
9-10. Fundy Gypsum Co.
11. National Gypsum (Canada) Ltd.
12. Georgia-Pacific Corp.
13-14. Little Narrows Gypsum Co.
15. Tusket Mining Incorporated

Limestone & Dolomite
16. Lafarge Canada Inc.
17. Nova Scotia Power Incorporated
18. Mosher Limestone Co. Ltd.
19. Ridge Brokers Ltd.
20. Scotia Limestone Ltd.

Salt
21. Sifto Canada Inc.
22. The Canadian Salt Company Limited

Silica Sand
23. Shaw Resources, a member of the Shaw Group Limited
24. Lafarge Canada Inc.

Dimension Stone
25. Heritage Memorials Ltd.
26. Scotia Slate Products Ltd.
27. Wallace Quarries Ltd.

Peat Moss
28. Annapolis Valley Peat Moss Co.
29. Clare Organic Products Limited
30. MacDonald Peat Moss Limited

Gold
31. Dufferin Resources Inc.

Figure 1.5. Location of industrial mineral and gold operations in Nova Scotia, 2000.

Table 1.6. Metallic mineral production for the calendar year 2000.

COMPANY	LOCATION	PRODUCTION		TOTAL NUMBER EMPLOYED[1]	APPROX. VALUE($)[2]
		TROY OZ.	g		
GOLD					
Dufferin Resources Inc.[1]	Port Dufferin, Halifax County	0	0	10	0
TOTAL FOR METALLIC MINERAL PRODUCTION					

[1]operated for part of year only
[2]value based on average annual metal price
NOTE: Production represents shipment

Mining at the Thorburn site, Pictou County, began in June 1995. In 2000, the mine operated during October and November to recover a small block of the remaining coal.

Coal was extracted from the McBean Seam crown pillar and from pillars remaining from the former underground mining operations. The pit was expanded slightly to the north during 2000. Overburden and waste rock were removed by ripping with bulldozers. Material was loaded and hauled using hydraulic excavators and dump trucks. The seam varies in thickness from 4 to 7 feet. The mining carried out in 2000 completes the coal recovery planned by the company for this mine.

Production from the Thorburn Mine is trucked to Pioneer Coal's facility in Stellarton for blending with other coals, and subsequently supplied to NSPI.

Coalburn Mine

Production: 35,197 tons (31 930 tonnes) of coal
Employees: 23

The Coalburn Surface Coal Mine is located in Coalburn, Pictou County. The mine began operations in June 1999, extracting coal from both the Upper and Lower MacKay seams. The seams are approximately 3 feet in thickness. In 2000, the operator obtained revised permits to employ blasting and to use a highwall miner at the property. The highwall miner is a remotely controlled system that extracts coal in a series of headings driven from the coal seam face in a surface cut.

Using surface mining methods, coal was extracted from both the Upper MacKay and the Lower Mackay seams in 2000. Where required, the overlying rock is broken by blasting and the material loaded and hauled using hydraulic excavators and off road haul trucks. The highwall miner was also successfully tested on the Upper MacKay seam during the year.

Production from the Coalburn Mine is trucked to Pioneer Coal's facility in Stellarton for blending with other coals, and subsequently supplied to NSPI.

CAPE CRUSHING COMPANY LIMITED

Manager: E. Brogan
Address: P. O. Box 265
North Sydney, N. S. B2A 3M3
Production: 12,770 tons (11 585 tonnes) of coal
Employees: 6

The company operates a small surface coal mine at Alder Point, Cape Breton County, to supply the local domestic market. The company's mining operation relocated to a new extraction area during the year. The new pit extracts coal from the Lloyd Cove (Bonar) Seam, in an area just south of previously mining, which was also on that seam. Mining is carried out using mechanical equipment to break the coal and overlying rock.

BROGAN MINING COMPANY LIMITED

Manager: R. Brogan
Address: 638 Bras d'Or Road
Florence, N. S. B1Y 1E4
Production: 60,627 tons (55 000 tonnes) of coal
Employees: 15

During the year, Brogan Mining Limited operated a surface coal mine at Little Pond, Cape Breton County. Coal is recovered from the Lloyd Cove (Bonar) coal seam. The overlying waste rock and coal are broken mechanically and mining is carried out using bulldozers, hydraulic excavators and dump trucks. The coal production is marketed to Nova Scotia Power Inc.

The company also carried out reclamation work at its mine sites at Toronto Road and Sullivan Creek, Cape Breton County, during 2000.

HILL RECLAMATION LTD.

Manager: M. McCormick
Address: R. R. #1
Springhill, N. S. B0M 1X0
Production: 11,105 tons (10 074 tonnes) of coal
Employees: 17

Hill Reclamation operates a rail bed coal recovery project near Springhill, Cumberland County. The company recovers coal from an abandoned railway bed and markets the coal to Nova Scotia Power Inc.

Industrial Minerals Mining

Gypsum and Anhydrite

FUNDY GYPSUM COMPANY

Manager: K. Hillman
Address: P. O. Box 400
Windsor, N. S. B0N 2T0
Production: 98,369 tons (89 238 tonnes) of anhydrite
1,912,522 tons (1 735 009 tonnes) of gypsum
Employees: 201

The Fundy Gypsum Company operates quarries and crushing plants in the Wentworth Road and Miller Creek areas near Windsor, Hants County. In 2000, the company produced gypsum from its Miller Creek quarry and both gypsum and anhydrite from the Wentworth quarry. The Wentworth ore is processed in the company's heavy media plant to separate the anhydrite and the gypsum.

The gypsum and anhydrite are transported by unit train to ship-loading facilities at Hantsport, a distance of 19 km. These products are shipped to wallboard and cement plants in the United States and Canada.

GEORGIA-PACIFIC CANADA, INC.

Manager: J. T. Kennedy
Address: P. O. Box 400
Port Hawkesbury, N. S. B0E 2V0
Production: 1,730,196 tons (1 569 606 tonnes) of gypsum
Employees: 117

Georgia-Pacific Corporation operates a gypsum quarry at Sugar Camp, Inverness County, and began development of a gypsum quarry at Melford, Inverness County, during 2000.

Overburden at Sugar Camp is removed using trucks and shovels. The gypsum is drilled, blasted and transported to the crusher by trucks. Most of the quarry's production is transported by highway trucks to ship-loading facilities at Point Tupper, Richmond County, a distance of 19 km. Georgia-Pacific also supplies gypsum to the wallboard plant at Point Tupper.

LITTLE NARROWS GYPSUM COMPANY

Manager: B. H. Allan
Address: R. R. #1
Little Narrows, N. S. B0E 1T0
Production: 98,004 tons (88 907 tonnes) of anhydrite
1,169,101 tons (1 060 590 tonnes) of gypsum
Employees: 102

Little Narrows Gypsum Company Limited operates a gypsum quarry and an anhydrite quarry near Little Narrows, Victoria County. All the gypsum and anhydrite produced is shipped from the company's dock on the Bras d'Or Lakes to destinations in Canada and the United States.

NATIONAL GYPSUM (CANADA) LTD.

Manager: P. C. Mills
Address: P. O. Box 57
Milford Station, N. S. B0N 1Y0
Production: 3,202,456 tons (2 905 217 tonnes)
Employees: 100

National Gypsum (Canada) Ltd. operates the largest gypsum quarry in the province at East Milford, Halifax County. The gypsum is drilled, blasted and loaded onto trucks with loaders and hydraulic excavators. The gypsum is crushed, screened, and transported by unit train from Milford to Wright's Cove, Dartmouth, a distance of 45 km, where it is loaded onto ships for points in Canada and the United States.

TUSKET MINING INC.

Manager: C. E. Bain
Address: P. O. Box 48100
Bedford, N. S. B4A 3Z2
Production: 0 tons (0 tonnes)

There was no activity at the Murchyville Mine, Halifax County, during the year. The site remains on a care and maintenance basis while markets for the gypsum are found.

Salt

THE CANADIAN SALT COMPANY LIMITED

Manager: A. W. Davidson
Address: P. O. Box 160
Pugwash, N. S. B0K 1L0
Production: 923,196 tons (837 509 tonnes) of salt
Employees: 197

The Canadian Salt Company Limited operates an underground salt mine at Pugwash, Cumberland County. The salt is mined by a room and pillar system of extraction, using diesel/electric drills, undercutters, loaders and trucks. The primary production during the year was from the 1000 level with secondary production from the 830 level.

The processing plant at the site produces a wide range of salt products, including industrial grades of salt, salt blocks for farm use, and refined salt for domestic consumption. Transportation is by road, rail or from the company owned ship-loading facility at Pugwash.

SIFTO CANADA INCORPORATED

Manager: D. E. Dickie
Address: P. O. Box 550
Amherst, N. S. B4H 4A1
Production: 82,112 tons (74 491 tonnes) of salt
Employees: 43

Salt has been produced from the solution salt mine at Nappan, Cumberland County, since 1947. Salt is mined by pumping water into underground wells where salt is dissolved and the resulting brine solution is then returned to the surface. The salt is recovered from the brine in a processing plant, using a 'mechanical vapour recompression evaporating process' system. The plant produces a wide range of refined salt products.

During the year, salt was produced from the Nos. 6, 7 and 8 brine wells.

Barite

E-Z-EM CANADA, INC., NYSTONE DIVISION

Manager: V. J. Prostak
Address: P. O. Box 69
Debert, N. S. B0M 1G0
Production: 543 tons (493 tonnes) of
pharmaceutical grade barite
Employees: 8

E-Z-EM Canada's barite deposit is located 1.6 km northeast of Brookfield, Colchester County. During 2000, approximately 3,313 tons of ore were produced from the surface mine. The ore was trucked to the company's plant at Debert where it was upgraded to a pharmaceutical quality product.

The refined product is shipped to the parent company, E-Z-EM Corporation, New York, USA, for further processing and packaging.

LYNX MINERALS INC.

Manager: G. W. Felderhof
Address: Box 6, Site 9, R. R. #1
Trenton, N. S. B0K 1Y0
Production: 0 tons of barite
Employees: 0

Lynx Minerals' barite deposit is located near Scotville, Inverness County. The company began initial production from the open pit mine in 1999; however, there was no production from the property in 2000. A diamond-drilling program was completed on the property during the year.

Limestone and Dolomite

LAFARGE CANADA INC.

Manager: D. Khan
Address: P. O. Box 5
Brookfield, N. S. B0N 1C0
Production: 817,356 tons (741 492 tonnes) of limestone
Employees: 16 (quarry) 52 (cement plant)

Lafarge Canada Inc. operates a limestone quarry near its Brookfield cement plant, 5 km west of Brookfield, Colchester County. The total production from the quarry is used at the cement plant.

MOSHER LIMESTONE COMPANY LIMITED

Manager: D. M. Mosher
Address: P. O. Box 28
Upper Musquodoboit, N. S. B0N 2M0
Production: 28,877 tons (26 197 tonnes) of dolomite/limestone
Employees: 30

Mosher Limestone operates a number of quarries near Upper Musquodoboit, Halifax County. The company produces agricultural grade dolomite/limestone in its grinding plant at Upper Musquodoboit. The product is bagged or supplied in bulk for distribution throughout the Atlantic Provinces. The company also produces a pelletized limestone product for the domestic garden market.

NOVA SCOTIA POWER INCORPORATED (OPERATED BY KELLY ROCK LIMITED)

Manager: D. W. MacKenna (Kelly Rock Limited)
Address: P. O. Box 1206
Sydney, N. S. B1P 6J9
Production: 110,970 tons (100 670 tonnes) of limestone
Employees: 10

The limestone quarry at Glen Morrison, Cape Breton County, began production in 1993. The company produces several products at the on-site milling facility. During 2000, most of the production from this site was shipped to Point Aconi for use in the fluidized bed power generating station. Kelly Rock Limited operates the quarry on behalf of Nova Scotia Power.

RIDGE BROKERS LIMITED

Manager: E. Alward
Address: P. O. Box 2001
Havelock, N. B. E4Z 6H3
Production: 20,451 tons (18 553 tonnes) of limestone
Employees: 1

The company operates a small quarry at Southside Antigonish Harbour, Antigonish County, producing limestone for the agricultural market.

SCOTIA LIMESTONE LIMITED

Manager: D. M. Mosher
Address: P. O. Box 28
Upper Musquodoboit, N. S. B0N 2M0
Production: 3,307 tons (3 000 tonnes) of dolomite
Employees: 2

The Kelly's Cove dolomite quarry and plant operation is located near New Campbellton, Victoria County. The plant produces an agricultural grade dolomite for domestic sale, a ground dolomite product for coal mine stone dust, and dolomite products for the offshore steel

industry. All 2000 production came from the existing ore inventory and no mining took place at the site during 2000.

Clay

SHAW BRICK, A MEMBER OF THE SHAW GROUP LIMITED

Manager: B. Frizzell
Address: P. O. Box 2130
Lantz, N. S. B0N 1R0

Production: 30,000 tons (27 216 tonnes) of clay & shale
Employees: 11

Shaw Brick extracts clay from pits at Lantz, Milford and Shubenacadie, all in Hants County, and shale from quarries located in Hardwood Lands, Hants County, and New Glasgow, Pictou County. These materials are used in the company's plant in Lantz for the manufacture of bricks and other structural clay products.

Silica Sand

LAFARGE CANADA INC.

Manager: D. Khan
Address: P. O. Box 5
Brookfield, N. S. B0N 1C0
Production: 110 tons (100 tonnes) of silica sand
Employees: Included with the Brookfield Quarry workforce

Lafarge Canada Inc. extracted 100 tonnes of silica sand from stockpiles at its Belmont sand pit.

SHAW RESOURCES, A MEMBER OF THE SHAW GROUP LIMITED

Manager: G. Dickie
Address: P. O. Box 60
Shubenacadie, N. S. B0N 2H0
Production: 92,975 tons (84 345 tonnes) of silica sand
Employees: 7

Shaw Resources produces silica sand from a deposit at West Indian Road, Hants County. This sand is processed into several silica sand products including glass-grade sand.

Dimension Stone

HERITAGE MEMORIALS LIMITED

Manager: G. Nelson
Address: P. O. Box 308
Windsor, N. S. B0N 2T0
Production: 1,654 tons (1 500 tonnes) of granite
Employees: 20

The company periodically operates a small quarry at Nictaux West, Annapolis County. The grey granite is used as dimension stone at the company's memorial manufacturing plant at Windsor, Hants County.

WALLACE QUARRIES LIMITED

Manager: S. Flynn
Address: P. O. Box 203
Wallace, N. S. B0K 1Y0
Production: 278 tons (252 tonnes) of building stone
Employees: 5

The Wallace Quarries, located near Wallace, Cumberland County, continued to supply building stone for major building rehabilitation work in Halifax and central Canada. Blocks of stone are sent for cutting to processing facilities in Nova Scotia, New Brunswick and Quebec to supply local markets.

Peat Moss

ANNAPOLIS VALLEY PEAT MOSS COMPANY LIMITED

President: H. Endres
Address: Berwick, N. S. B0P 1E0
Production: 4,900 tons (4 445 tonnes) of peat moss
Employees: 25

The company uses vacuum harvesters to recover agricultural peat from a 500 acre (200 ha) bog located near Berwick, Kings County. Baled peat products are shipped to markets in Canada, the

United States and Japan.

CLARE ORGANIC PRODUCTS LIMITED

Owner: Gerald Thimot
Address Box 174-A, Saulnierville
Digby County, N. S. B0W 2Z0
Production: 5,000 tons (4 536 tonnes) of peat moss (estimated)
Employees: 20

The company uses vacuum harvesters to recover agricultural peat from a 200 acre (81 ha) bog located near Meteghan Station, Digby County. The company has a contract to supply a major Maritime peat producer with baled peat destined for international markets.

MACDONALD PEAT MOSS LIMITED

Owner: Lameque Quality Group Ltd.
Address 86 Tourbe Street
Lameque, N. B. E8T 1A3
Production: 7,293 tons (6 616 tonnes) of peat moss (estimated)
Employees: 5

MacDonald Peat Moss Limited, a wholly-owned subsidiary of New Brunswick's Lameque Quality Group Ltd., has lease rights to a 1700 acre (688 ha) peat bog located on Crown land, approximately 12 km west of Kennetcook, Hants County. The company began operations in 1999, exporting baled peat to international markets.

Aggregate Resources

Approximately 9.5 million tonnes of construction aggregates were produced in Nova Scotia in 2000. Twenty-five companies reported crushed stone production totaling 7.6 million tonnes while 30 producers reported sand and gravel production totaling 1.9 million tonnes. The majority of the aggregates were consumed within the province, with approximately 2 million tonnes exported.

Three companies eclipsed the 1 million tonne mark for crushed stone production in 2000. Rocky Lake Quarry Limited of Bedford, Nova Scotia, reported shipments of over 1.5 million tonnes, Conrad Brothers of Dartmouth produced 1.0 million tonnes and Martin Marietta Materials Canada Ltd. reported just over 2.2 million tonnes shipped.

Appendix 2

Minerals and Energy Branch Geoscience Maps and Publications for Sale

BEDROCK GEOLOGY MAPS

Provincial Scale

1:2 000 000

Map ME 1979-5 to Map ME 1979-9 Folio of Geological Maps of Nova Scotia - includes Geological, Structural, Metamorphic, Classes of Mineral Deposits, Bouguer Gravity Anomaly and Magnetic Maps, by J. D. Keppie, G. K. Muecke, A. K. Chatterjee and others, scale 1:2 000 000, 1979. **$1.00** (Please note that Geological Map ME 2000-1 is the most recent provincial scale geology map of Nova Scotia)

1:1 000 000

OFM ME 1999-1 Index map to Nova Scotia Department of Natural Resources Bedrock Geology, Surficial Geology and Aeromagnetic Open File Maps of Nova Scotia [scale 1:1 000 000], compiled by K. D. Fraser, 1999, 1 map. **$5.00**

1:640 000

Outside Publication ME 1989-1 Geological Highway Map of Nova Scotia, Second Edition, by Howard V. Donohoe, Jr., and R. G. Grantham, scale 1:640 000, 1989 (Atlantic Geoscience Society, Special Publication Number 1). **$3.50**

1:500 000

Map ME 2000-1 Geological Map of the Province of Nova Scotia, compiled by J. D. Keppie, 2000, scale 1:500 000. **$20.00**

Regional Scale

1:250 000

Map ME 1994-1 Geological Map of the South Mountain Batholith, Western Nova Scotia, compiled by M. A. MacDonald with contributions from M. C. Corey, L. J. Ham and R. J. Horne, 1994, scale 1:250 000. **$6.00**

1:125 000

Map ME 1983-4 Geological Map of the Red River Anorthosite Complex, Inverness and Victoria Counties, Nova Scotia, by P. K. Smith and A. S. Macdonald, scale 1:125 000. **$1.50**

Map ME 1978-1 Preliminary Geology Map of the Cobequid Highlands, by H. V. Donohoe and P. I. Wallace, scale 1:125 000, (Superseded by Map ME 1982-6, Map ME 1982-7, Map ME 1982-8, Map ME 1982-9, scale 1:50 000). **$3.50**

1:100 000

OFM ME 1998-1 Preliminary Geological Map of Guysborough, Richmond and Antigonish Counties (parts of NTS sheets 11E/08, 11F/05, 11F/06, 11F/10, 11F/11, 11F/12 and 11F/15, Nova Scotia, Canada, by C. E. White and S. M. Barr, 1998, 1 coloured map, scale 1:100 000. **$5.00**

Map ME 1984-2 Geological Map of the Boisdale Peninsula, Central Cape Breton Island, Cape Breton County, Nova Scotia, by Sandra M. Barr and Jeremy R. D. Setter, 1984, scale 1:100 000. **$4.00**

Map ME 1979-014 Pleistocene geology map of the Eastern Shore Region, Halifax and Guysborough Counties, Nova Scotia [sheet 3 of 3] [11D/14, 11D/15 and 11E/02 and parts of 11D/11 and 11E/03] [1:100 000], by R. R. Stea, J. H. Fowler, Nova Scotia Department of Mines and Energy, 1979, 1 map. [This map accompanies Nova Scotia Department of Mines and Energy Paper ME 1979-4.]

Map ME 1979-013 Pleistocene geology map of the Eastern Shore Region, Guysborough and Halifax Counties, Nova Scotia [sheet 2 of 3] [11E/01 and parts of 11E/02, 11E/07, 11E/08, 11E/11, 11F/04, 11F/05, 11C/13, 11D/15 and 11D/16] [1:100 000], by R. R. Stea, J. H. Fowler, Nova Scotia Department of Mines and Energy, 1979, 1 map. [This map accompanies Nova Scotia Department of Mines and Energy Paper ME 1979-4.]

Map ME 1979-012 Pleistocene geology map of the Eastern Shore Region, Guysborough County, Nova Scotia [sheet 1 of 3] [11F/06 and parts of 11F/03, 11F/04, 11F/05, 11F/07, 11F/11 and 11F/12] [1:100 000], by R. R. Stea, J. H. Fowler, Nova Scotia Department of Mines and Energy, 1979, 1 map. [This map accompanies Nova Scotia Department of Mines and Energy Paper ME 1979-4.]

Detailed Scale

1:50 000

Map ME 2001-1 Geological Map of the Meguma Group in the Rawdon Area [part of 11E/04], Hants County, Nova Scotia, by Richard J. Horne, Lisa A. MacDonald, M. Steve King, 2001; 1 colour map, scale 1:50 000. Includes geological bedrock data, mineral occurrence locations, diamond-drill hole locations, perspective diagram of digital elevation and aeromagnetic data with geological cross section, stereonets of structural data and index maps. **$5.00**

OFM ME 2000-3 Preliminary Geological Map of the Wolfville/Windsor Area, Hants and Kings Counties, Nova Scotia [21H/01 and Parts of 21A/16C and D], compiled by R. G. Moore, S. A. Ferguson, R. C. Boehner, C. M. Kennedy, 2000, 1 colour map, scale 1:50 000. **$5.00**

OFM ME 1999-3 Geological Map of the Musquodoboit Batholith, Halifax County [part of NTS sheet 11D/15], Nova Scotia, by L. J. Ham, 1999, 1 colour map, scale 1:50 000. **$5.00**

OFM ME 1999-2 Geological Map of the Musquodoboit Batholith, Halifax County [part of NTS sheet 11D/14], Nova Scotia, by L. J. Ham, 1999, 1 colour map, scale 1:50 000. **$5.00**

Map ME 1996-1 Geological Map of the Shubenacadie and Musquodoboit Basins Showing the Extent of Early Cretaceous Sediments (part of NTS Map Sheet 11E/03), Colchester and Halifax Counties, Nova Scotia, by R. R. Stea, P. W. Finck, S. E. Pullan, and M. C. Corey, 1996, scale 1:50 000. **$6.00**

Map ME 1994-8 Geological Map of Bridgetown, Nova Scotia (NTS Sheet 21A/14): South Mountain Batholith Project, by M. A. MacDonald and L. J. Ham, 1994, scale 1:50 000. **$6.00**

Map ME 1994-7 Geological Map of Digby, Nova Scotia (NTS Sheet 21A/12): South Mountain Batholith Project, by L. J. Ham, 1994, scale 1:50 000. **$6.00**

Map ME 1994-6 Geological Map of Milford, Nova Scotia (NTS Sheet 21A/11): South Mountain Batholith Project, by M. C. Corey and R. J. Horne, 1994, scale 1:50 000. **$6.00**

Map ME 1994-5 Geological Map of Kejimkujik Lake, Nova Scotia (NTS Sheet 21A/06 and part of 21A/07): South Mountain Batholith Project, by R. J. Horne and M. C. Corey, 1994, scale 1:50 000. **$6.00**

Map ME 1994-4 Geological Map of Weymouth, Nova Scotia (NTS Sheet 21A/05): South Mountain Batholith Project, by M. A. MacDonald and L. J. Ham, 1994, scale 1:50 000. **$6.00**

Map ME 1994-3 Geological Map of Wentworth Lake (NTS Sheet 21A/04 and part of 20P/13): South Mountain Batholith Project, by L. J. Ham and M. A. MacDonald, 1994, scale 1:50 000. **$6.00**

Map ME 1994-2 Geological Map of Lake Rossignol, Nova Scotia (NTS Sheet 21A/03 West

Half): South Mountain Batholith Project, by M. C. Corey and R. J. Horne, 1994, scale 1:50 000. **$6.00**

Map ME 1993-1 Geological Map of New Germany (NTS Sheet 21A/10), Nova Scotia, by R. J. Horne, 1992, scale 1:50 000. **$6.00**

Map ME 1992-1 Geological Map of Gaspereau Lake (NTS Sheet 21A/15 and part of 21H/02), Nova Scotia, by M. A. MacDonald and L. J. Ham, 1992, scale 1:50 000. **$6.00**

Map ME 1990-14 Cumberland Basin Geology Map, Tatamagouche and Malagash, Cumberland, Colchester and Pictou Counties, by R. J. Ryan and R. C. Boehner, 1990, scale 1:50 000. **$6.00**

Map ME 1990-13 Cumberland Basin Geology Map, Oxford and Pugwash, Cumberland County, by R. J. Ryan, R. C. Boehner and A. Deal, 1990, scale 1:50 000. **$6.00**

Map ME 1990-12 Cumberland Basin Geology Map, Amherst, Springhill and Parrsboro, Cumberland County, by R. J. Ryan, R. C. Boehner, A. Deal and J. H. Calder, 1990, scale 1:50 000. **$6.00**

Map ME 1990-11 Cumberland Basin Geology Map, Apple River and Cape Chignecto, Cumberland County, by R. J. Ryan, R. C. Boehner and A. Deal, 1990, scale 1:50 000. **$6.00**

Map ME 1990-10 Geological Map of Windsor (21A/16, West Half and part of 21H/01), Nova Scotia, by L. J. Ham, scale 1:50 000. **$6.00**

Map ME 1990-9 Geological Map of Chester (21A/09), Nova Scotia, by M. C. Corey, scale 1:50 000. **$7.00**

Map ME 1989-4 Geology of Mabou Highlands (NTS sheet 11K/03, west half), Nova Scotia, by S. M. Barr and A. S. Macdonald, 1989, colour map, scale 1:50 000 (accompanies Paper ME 1989-2). **$3.00**

Map ME 1987-8 Bedrock Geological Map of Mount Uniacke (11D/13 West), by M. C. Corey, 1987, scale 1:50 000. **$6.00**

Map ME 1987-7 Bedrock Geological Map of Windsor (21A/16 East), by L. J. Ham and R. J. Horne, 1987, scale 1:50 000. **$6.00**

Map ME 1987-6 Bedrock Geological Map of Halifax and Sambro (11D/12 and 11D/05), by M. A. MacDonald and R. J. Horne, 1987, scale 1:50 000. **$6.00**

Map ME 1986-1 Geological Map of the Sydney Basin, Cape Breton Island, Nova Scotia, by R. C. Boehner and P. S. Giles, 1986, scale 1:50 000. **$5.00**

Map ME 1985-2 Geological Map of the Loch Lomond Basin and Glengarry Half Graben, by R. C. Boehner and G. Prime, scale 1:50 000. **$5.00**

Map ME 1982-9 Geological Map of the Cobequid Highlands, Colchester, Cumberland and Pictou Counties, Nova Scotia, Debert - Mt. Thom Region, Sheet 4 of 4, by H. V. Donohoe, Jr., and P. I. Wallace, scale 1:50 000. **$8.00 each, $25.00 set of Map ME 1982-6 to Map ME 1982-9**

Map ME 1982-8 Geological Map of the Cobequid Highlands, Colchester, Cumberland and Pictou Counties, Nova Scotia, Economy River - Folly Lake Region, Sheet 3 of 4, by H. V. Donohoe, Jr., and P. I. Wallace, scale 1:50 000. **$8.00 each, $25.00 set of Map ME 1982-6 to Map ME 1982-9**

Map ME 1982-7 Geological Map of the Cobequid Highlands, Colchester, Cumberland and Pictou Counties, Nova Scotia, Parrsboro - Five Islands Region, Sheet 2 of 4, by H. V. Donohoe, Jr., and P. I. Wallace, scale 1:50 000. **$8.00 each, $25.00 set of Map ME 1982-6 to Map ME 1982-9**

Map ME 1982-6 Geological Map of the Cobequid Highlands, Colchester, Cumberland and Pictou Counties, Nova Scotia, Advocate Harbour - Port Granville Region, Sheet 1 of 4, by H. V. Donohoe, Jr., and P. I. Wallace, scale 1:50 000. **$8.00 each, $25.00 set of Map ME 1982-6 to Map ME 1982-9**

Map ME 1982-5 Geological Map of the Northern Antigonish Highlands, Nova Scotia, by J. B. Murphy, J. D. Keppie and A. Hynes, scale 1:50 000. **$4.00**

Map ME 1982-4 Geological Map of the Shubenacadie and Musquodoboit Basins, by P. S. Giles and R. C. Boehner, scale 1:50 000. **$5.00**

Map ME 1982-3 Geological Map of the Eureka Area, by P. S. Giles, scale 1:50 000. **$3.00**

Map ME 1982-2 Geological Map of the Antigonish Basin, by R. C. Boehner and P. S. Giles, scale 1:50 000. **$3.00**

1:31 680

Map ME 1967-3 Geology, Area of Christopher McLeod Brook, Victoria County, Nova Scotia, by G. C. Milligan, B. White, R. M. Creed and A. K. Chatterjee, 1967, colour map, scale 1:31 680 (accompanies Memoir ME 7). **$3.00**

Map ME 1967-2 Geology, Middle River Area, Inverness and Victoria Counties, Nova Scotia, by G. C. Milligan, B. White, R. M. Creed and A. K. Chatterjee, 1967, colour map, scale 1:31 680 (accompanies Memoir ME 7). **$3.00**

Map ME 1967-1 Geology, Crowdis Mountain Area, Victoria County, Nova Scotia, by G. C. Milligan, R. C. Parsons, B. White, R. M. Creed and A. K. Chatterjee, 1967, colour map, scale 1:31 680 (accompanies Memoir ME 7). **$3.00**

Map ME 1963-2 Geology, Boisdale Hills, Scotch Lake to Steeles Crossing, Cape Breton County, Nova Scotia, by G. C. Milligan and R. C. Parsons, 1963, colour map, scale 1:31 680 (accompanies Memoir ME 7). **$3.00**

Map ME 1963-1 Geological Map of the Craignish Hills, Inverness County, Nova Scotia, by G. C. Milligan and R. C. Parsons, 1963, colour map, scale 1:31 680 (accompanies Memoir ME 7). **$3.00**

Map ME 1962-1 Geology, North Mountain, Inverness County, Nova Scotia, by G. C. Milligan and R. C. Parsons, 1962, black/white map, scale 1:31 680 (accompanies Memoir ME 7). **$1.00**

1:25 000

Map ME 1997-1 Geological Map of a Portion of the South-Central Cape Breton Highlands (part of NTS map sheet 11K/07), Victoria and Inverness Counties, Nova Scotia, by L. J. Ham, 1997, scale 1:25 000. Accompanies Paper ME 1997-1. **$6.00**

Map ME 1995-2, Second Edition Geological Map of a Portion of the South-Central Cape Breton Highlands (parts of NTS Map Sheets 11K/07 and 11K/10), Victoria and Inverness Counties, Nova Scotia, by R. J. Horne, revised September 1996, scale 1:25 000. **$6.00**

OFM ME 1994-6 Bedrock Geology Map of the Southeast Cape Breton Highlands, Nova Scotia (part of NTS Sheet 11K/07), Inverness and Victoria Counties, by L. J. Ham, 1994, scale 1:25 000. **$2.00**

OFM ME 1994-2 Location Map of Bedrock Samples, South-Central Cape Breton Highlands (NTS Sheets 11K/07 and 11K/10), Inverness and Victoria Counties, Nova Scotia, by R. J. Horne and L. J. Ham, 1994, scale 1:25 000 (2 sheets). **$4.00**

OFM ME 1994-1 Bedrock Geology Map of the South-Central Cape Breton Highlands, Nova Scotia (parts of NTS Sheets 11K/07 and 11K/10), Inverness and Victoria Counties, by R. J. Horne, 1994, scale 1:25 000. **$2.00**

OFM ME 1991-1 Preliminary Geological Map of West-Central Cape Breton Highlands (11K/07 and 11K/10), by R. J. Horne, 1991, scale 1:25 000. **$2.00**

Map ME 1986-2 Geological Map of the Windsor Area, Nova Scotia, by Reginald G. Moore and Stewart A. Ferguson, 1986, scale 1:25 000. **$5.00**

Map ME 1983-1 Geological Map of the Hantsport Area, Nova Scotia, compilation and geology by S. A. Ferguson, scale 1:25 000. **$5.00**

1:20 000

OFM ME 1998-14 Geological Map of the McAdams Lake area, Cape Breton County (parts of NTS sheets 11F/15, 11F/16, 11K/01 and 11K/02) Nova Scotia, by C. E. White and S. M. Barr, 1998, 1 colour map, scale 1:20 000. **$5.00**

1:10 000

OFM ME 1998-13 Geological Map of Renfrew (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne and D. Fox, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-12 Geological Map of Bill Meadow Mountain (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne and D. Fox, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-11 Geological Map of Woodville (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne, Nova Scotia Department of Natural Resources, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-10 Geological Map of Newport Corner (part of NTS sheet 11D/13), Hants County, Nova Scotia, by R. J. Horne, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-9 Geological Map of Waverley (part of NTS sheet 11D/13), Halifax County, Nova Scotia, by R. J. Horne, D. E. Baker and L. J. Ham, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-8 Geological Map of Middle Sackville (part of NTS sheet 11D/13), Halifax County, Nova Scotia, by R. J. Horne, L. A. MacDonald and D. E. Baker, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-7 Geological Map of Lucasville (part of NTS sheet 11D/13), Halifax County, Nova Scotia, by R. J. Horne and L. A. MacDonald, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-6 Geological Map of Fall River (part of NTS sheet 11D/13), Halifax County, Nova Scotia, by R. J. Horne and D. E. Baker, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-5 Geological Map of Soldier Lake (part of NTS sheet 11D/13), Halifax County, Nova Scotia, by M. Feetham, R. J. Horne, D. E. Baker and L. J. Ham, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-4 Geological Map of Halifax Airport (part of NTS sheet 11D/13), Halifax County, Nova Scotia, by D. E. Baker, R. J. Horne and M. Feetham, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1997-6 Geological Map of Gore (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne, 1997, scale 1:10 000. **$5.00**

OFM ME 1997-5 Geological Map of Greenfield (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne, 1997, scale 1:10 000. **$5.00**

OFM ME 1997-4 Geological Map of Greenhill (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne, 1997, scale 1:10 000. **$5.00**

OFM ME 1997-3 Geological Map of East Gore (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne, 1997, scale 1:10 000. **$5.00**

OFM ME 1997-2 Geological Map of Upper Rawdon (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne, 1997, scale 1:10 000. **$5.00**

OFM ME 1997-1 Geological Map of Upper Nile Mile River (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne, 1997, scale 1:10 000. **$5.00**

Map ME 1995-1 Geological Map of the Springhill Coalfield, Cumberland County, Nova Scotia, by J. H. Calder, 1995, scale 1:10 000. **$6.00**

OFM ME 1994-5 Preliminary Geological Map, Rawdon Area, Hants County, Nova Scotia (NTS Sheet 11E/04), by R. J. Horne, 1994, scale 1:10 000. **$2.00**

OFM ME 1993-2 Geological Map of the Cogmagun River - Goshen Quadrangle (NTS 21H/01), Nova Scotia, by R. G. Moore, 1993, scale 1:10 000. **$2.00**

OFM ME 1993-1 Geological Map of the Cheverie - Lower Burlington Quadrangle (NTS 21H/01), Nova Scotia, by R. G. Moore, 1993, scale 1:10 000. **$2.00**

OFM ME 1992-6 Geological Map of the Debert - Kemptown Coalfield (parts of NTS 11E/05, 06, 07, 11, 12), by R. Naylor, 1992, scale 1:10 000 (6 sheets). **$12.00 set**

OFM ME 1989-1 Geological Map of the Kentville-South Alton Quadrangle, compiled by Stewart A. Ferguson, 1989, scale 1:10 000. **$2.00**

OFM ME 1989-3 Geological Map of the Newport Corner Quadrangle, by R. G. Moore, 1988, scale 1:10 000. **$2.00**

OFM ME 1989-2 Geological Map of the West Gore Quadrangle, by R. G. Moore, 1988, scale 1:10 000. **$2.00**

OFM ME 1988-43 Preliminary Geological Maps of the Cumberland Basin, Amherst (21H/16), by R. C. Boehner, R. J. Ryan and A. Deal, 11 maps, scale 1:10 000. **$2.00 each**

OFM ME 1988-42 Preliminary Geological Maps of the Cumberland Basin, Springhill and Apple River (21H/09 and 21H/10), by R. J. Ryan, A. Deal, J. H. Calder and R. C. Boehner, 24 maps, scale 1:10 000. **$2.00 each**

OFM ME 1988-41 Preliminary Geological Maps of the Cumberland Basin, Cape Chignecto and Parrsboro (21H/07 and 21H/08), by A. Deal, R. J. Ryan and R. C. Boehner, 13 maps, scale 1:10 000. **$2.00 each**

OFM ME 1988-40 Preliminary Geological Maps of the Cumberland Basin, Pugwash and Malagash (11E/13 and 11E/14), by R. J. Ryan, R. C. Boehner and A. Deal, 21 maps, scale 1:10 000. **$2.00 each**

OFM ME 1988-39 Preliminary Geological Maps of the Cumberland Basin, Tatamagouche and Oxford (11E/11 and 11E/12), by R. J. Ryan, R. C. Boehner and A. Deal, 23 maps, scale 1:10 000. **$2.00 each**

OFM ME 1988-24 Geological Map of New Minas - Canaan Quadrangle, compiled by Dr. Stewart A. Ferguson 1988, scale 1:10 000. **$2.00**

1:6000

OFM ME 1990-2 Map of the Glencoe Limestone Deposit, Inverness County (11F/14), 1988 Diamond-Drilling; Diamond-Drill Holes and Sections, by R. H. MacDonald, scale 1:6000. **$2.00**

1:5000

OFM ME 1989-17 Geological Map of the Stellarton Basin (West Half), Pictou County, Nova Scotia, by W. D. Smith, K. S. Gillis, S. A. Montgomery, scale 1:5000. **$2.00**

1:1600

Map ME 1990-3 Geological Map of the Canadian Salt Company Limited Pugwash Mine (11E/13A), 830 Level, Pugwash, Nova Scotia, by D. C. Carter, 1990, scale 1:1600. **$5.00**

Map ME 1990-2 Geological Map of the Canadian Salt Company Limited Pugwash Mine (11E/13A), 730 Level, Pugwash, Nova Scotia, by D. C. Carter, 1990, scale 1:1600. **$5.00**

Map ME 1990-1 Geological Map of the Canadian Salt Company Limited Pugwash Mine (11E/13A), 630 Level, Pugwash, Nova Scotia, by D. C. Carter, 1990, scale 1:1600. **$5.00**

1:240

Map ME 1968-1 Silver Cliff Prospect, Dauphinee Brook, Inverness County, Nova Scotia, by G. C. Milligan and A. K. Chatterjee, 1968, black/white map, scale 1:240 (accompanies Memoir ME 7). **$1.00**

1:70

Map ME 1984-1 Geological Map of the Cochrane Hill Open-Pit Gold Deposit, Guysborough County, Nova Scotia, by P. K. Smith, scale 1:70. **$8.00**

GLACIAL/SURFICIAL GEOLOGY MAPS

Provincial Scale

1:1 000 000

OFM ME 1999-1 Index map to Nova Scotia Department of Natural Resources Bedrock Geology, Surficial Geology and Aeromagnetic Open File Maps of Nova Scotia [scale 1:1 000 000], compiled by K. D. Fraser, 1999, 1 map. **$5.00**

1:500 000

Map ME 1992-3 Surficial Geology Map of the Province of Nova Scotia, compiled by R. R. Stea, H. Conley and Y. Brown, 1992, scale 1:500 000. **$5.00**

Regional Scale

1:250 000

Map ME 1992-2 Glacial Geology Map of the South Mountain Batholith (NTS Sheets 11D, 21A and 20P), Western Nova Scotia, by P. W. Finck, R. M. Graves and F. J. Boner, 1992, scale 1:250 000. **$5.00**

Map ME 1989-3 Map of the Peatland Areas of Nova Scotia, by A. R. Anderson and W. A. Broughm, Sheet 3 (Cape Breton Island), 1986, scale 1:250 000 (accompanies Bulletin ME 6). **$2.00 (white print copies only)**

Map ME 1989-2 Map of the Peatland Areas of Nova Scotia, by A. R. Anderson and W. A. Broughm, Sheet 2 (Central Nova Scotia), 1986, scale 1:250 000 (accompanies Bulletin ME 6). **$2.00 (white print copies only)**

Map ME 1989-1 Map of the Peatland Areas of Nova Scotia, by A. R. Anderson and W. A. Broughm, Sheet 1 (Southwestern Nova Scotia), 1986, scale 1:250 000 (accompanies Bulletin ME 6). **$2.00 (white print copies only)**

Map ME 1985-6 Aggregate Resources Map, Cape Breton Island, by W. J. Wright, scale 1:125 000 (locates and shows the type, quality and observed thickness of sand and gravel deposits). **$3.00**

Map ME 1985-3, Map ME 1985-4, Map ME 1985-5 Aggregate Resources Map, Cape Breton Island, by W. J. Wright, scale 1:125 000, (locates and names aggregate pits and quarries). **$3.00 each, $10.00 set**

1:100 000

Map ME 1990-6 Surficial Geology Map of Parts of Halifax, Pictou, Antigonish and Guysborough Counties (Sheet 12), Map Sheets 11E/09, 10, 15, 16 and parts of 11E/07 and 11E/08, by R. R. Stea and R. A. Myers, 1990, scale 1:100 000. **$13.00**

OFM ME 1988-51 Till Geochemistry Map of Northern Mainland Nova Scotia, Heavy Mineral Separate Analyses, Antigonish and Guysborough Counties, by R. G. Turner and R. R. Stea, Map Sheet 13-88, scale 1:100 000. **$2.00**

OFM ME 1988-50 Till Geochemistry Map of Northern Mainland Nova Scotia, Clay Fraction Analyses, Antigonish and Guysborough Counties, by R. G. Turner and R. R. Stea, Map Sheet 13-88, scale 1:00 000. **$2.00**

OFM ME 1988-32 Till Geochemistry Map, Northern Mainland Nova Scotia, Heavy Mineral Separate Analyses (Sheet 12), by R. G. Turner and R. R. Stea, scale 1:100 000. **$2.00**

OFM ME 1988-31 Till Geochemistry Map, Pictou and Antigonish Counties (Sheet 12), by R. G. Turner and R. R. Stea, scale 1:100 000. **$2.00**

Map ME 1988-14 Surficial Geology Map of Parts of Colchester, Cumberland, Pictou and Hants Counties, Nova Scotia (Sheet 11), by R. R. Stea and P. W. Finck, 1988, scale 1:100 000. **$4.00**

Map ME 1988-13 Surficial Geology Map of Parts of Colchester, Cumberland, Pictou and Hants Counties, Nova Scotia (Sheet 10), by R. R. Stea and P. W. Finck, 1988, scale 1:100 000. **$4.00**

Map ME 1982-10 Pleistocene Geology and Till Geochemistry Map of Southwestern Nova Scotia (Sheets 7 and 8), by R. R. Stea and D. R. Grant, scale 1:100 000, (Sheet 9 is Map 1630A in Geological Survey of Canada Paper 85-17). **$8.00**

Map ME 1982-1 Pleistocene Geology and Till Geochemistry Map of South-Central Nova Scotia (Sheet 6), by R. R. Stea, scale 1:100 000, (Sheet 5 is in Open File Report ME 555). **$3.50**

Map ME 1981-1 Pleistocene Geology and Till Geochemistry Map, Central Nova Scotia, (Sheet 4; Sheets 1, 2 and 3 are in Paper ME 1979-4), by R. R. Stea and J. H. Fowler, scale 1:100 000. **$3.50**

Detailed Scale

1:50 000

OFM ME 1998-3 Surficial Geology of the Shubenacadie area (NTS 11E/03), Colchester, Halifax and Hants Counties, Nova Scotia, by R. R. Stea and C. M. Kennedy, 1998, 1 coloured map, scale 1:50 000. **$5.00**

OFM ME 1998-2 Surficial Geology of the Bridgetown area (NTS 21A/14), Annapolis County, Nova Scotia, by R. R. Stea and C. M. Kennedy, 1998, 1 coloured map, scale 1:50 000. **$5.00**

Map ME 1994-14 Glacial and Till Clast Geology Map of Gaspereau Lake, Nova Scotia (NTS Sheet 21A/15): South Mountain Batholith Project, by P. W. Finck, R. M. Graves, F. J. Boner and H. B. Bent, 1994, scale 1:50 000. **$6.00**

Map ME 1994-13 Glacial and Till Clast Geology Map of Milford, Nova Scotia (NTS 21A/11): South Mountain Batholith Project, by F. J. Boner, P. W. Finck and R. M. Graves, 1994, scale 1:50 000. **$6.00**

Map ME 1994-12 Glacial and Till Clast Geology Map of Kejimkujik Lake, Nova Scotia (NTS Sheets 21A/06 plus part of 21A/07): South Mountain Batholith Project, by P. W. Finck, F. J. Boner and R. M. Graves, 1994, scale 1:50 000. **$6.00**

Map ME 1994-11 Glacial and Till Clast Geology Map of Weymouth, Nova Scotia (NTS Sheet 21A/05): South Mountain Batholith Project, by P. W. Finck, R. M. Graves and F. J. Boner, 1994, scale 1:50 000. **$6.00**

Map ME 1994-10 Glacial and Till Clast Geology Map of Wentworth Lake, Nova Scotia (NTS Sheet 21A/04 plus part of 20P/13): South Mountain Batholith Project, by P. W. Finck, F. J. Boner and R. M. Graves, 1994, scale 1:50 000. **$6.00**

Map ME 1994-9 Glacial and Till Clast Geology Map of Lake Rossignol, Nova Scotia (NTS Sheet 21A/03 West): South Mountain Batholith Project, by P. W. Finck, R. M. Graves and F. J. Boner, 1994, scale 1:50 000. **$6.00**

OFM ME 1993-13 Glacial and Till Clast Geology Map of Digby (NTS 21A/12), Nova Scotia, by P. W. Finck, R. M. Graves and F. J. Boner, 1993, scale 1:50 000. **$2.00**

Map ME 1993-2 Glacial and Till Clast Geology Map of New Germany (NTS Sheet 21A/10), Nova Scotia, by P. W. Finck, R. M. Graves and F. J. Boner, 1992, scale 1:50 000. **$6.00**

OFM ME 1991-5 to OFM ME 1991-18 Aggregate Potential of Cumberland and Colchester Counties, 14 Preliminary Map Sheets, scale 1:50 000 (11E/02, 11E/03, 11E/05, 11E/06, 11E/07, 11E/11, 11E/12, 11E/13, 11E/14, 21H/07, 21H/08, 21H/09, 21H/10, 21H/16), by G. Prime, 1991. **$2.00 per NTS Map Sheet**

Map ME 1990-4 Till Clast and Glacial Geology Map of Chester (21A/09), Nova Scotia, by R. M. Graves and P. W. Finck, 1990, scale 1:50 000. **$11.00**

OFM ME 1988-52 Preliminary Till Geochemistry and Till Clast Geology of the Windsor Map Sheet (21A/16), South Mountain Batholith Project, by F. J. Boner, P. W. Finck and R. M. Graves, scale 1:50 000. **$2.00**

OFM ME 1988-14 Glacial and Till Clast Geology of the Windsor Map Sheet (21A/16), South Mountain Batholith Project, by P. W. Finck, R. M. Graves, F. J. Boner and H. G. Bent, scale 1:50 000. **$2.00**

Map ME 1987-4 Till Clast and Simplified Glacial Geology Map of Halifax-Sambro (11D/12 and 11D/05), by R. M. Graves and P. W. Finck, 1987, scale 1:50 000. **$6.00**

Map ME 1987-3 Till Clast and Simplified Glacial Geology Map of Mount Uniacke (11D/13 West), by R. M. Graves and P. W. Finck, 1987, scale 1:50 000. **$6.00**

Map ME 1987-2 Glacial Geology Map of Halifax and Sambro (11D/12 and 11D/05), by P. W. Finck and R. M. Graves, 1987, scale 1:50 000. **$6.00**

Map ME 1987-1 Glacial Geology Map of Mount Uniacke (11D/13 West), by P. W. Finck and R. M. Graves, 1987, scale 1:50 000. **$6.00**

1:25 000

OFM ME 1992-2 Surficial Geology of the South-Central Cape Breton Highlands (11K/07), by P. W. Finck, 1992, scale 1:25 000. **$2.00**

GEOCHEMISTRY MAPS

Provincial Scale

1:1 500 000

OFM ME 1990-15 Geochemical Atlas of Nova Scotia: Part I, Drainage Surveys, compiled by P. A. Lombard, 119 maps, 4 overlays. **$50.00**

Regional Scale

1:100 000

OFM ME 1988-51 Till Geochemistry Map of Northern Mainland Nova Scotia, Heavy Mineral Separate Analyses, Antigonish and Guysborough Counties, by R. G. Turner and R. R. Stea, Map Sheet 13-88, scale 1:100 000. **$2.00**

OFM ME 1988-50 Till Geochemistry Map of Northern Mainland Nova Scotia, Clay Fraction Analyses, Antigonish and Guysborough Counties, by R. G. Turner and R. R. Stea, Map Sheet 13-88, scale 1:00 000. **$2.00**

OFM ME 1988-32 Till Geochemistry Map, Northern Mainland Nova Scotia, Heavy Mineral Separate Analyses (Sheet 12), by R. G. Turner and R. R. Stea, scale 1:100 000. **$2.00**

OFM ME 1988-31 Till Geochemistry Map, Pictou and Antigonish Counties (Sheet 12), by R. G. Turner and R. R. Stea, scale 1:100 000. **$2.00**

Map ME 1982-10 Pleistocene Geology and Till Geochemistry Map of Southwestern Nova Scotia (Sheets 7 and 8), by R. R. Stea and D. R. Grant, scale 1:100 000, (Sheet 9 is Map 1630A in Geological Survey of Canada Paper 85-17). **$8.00**

Map ME 1982-1 Pleistocene Geology and Till Geochemistry Map of South-Central Nova Scotia (Sheet 6), by R. R. Stea, scale 1:100 000, (Sheet 5 is in Open File Report ME 555). **$3.50**

Map ME 1981-1 Pleistocene Geology and Till Geochemistry Map, Central Nova Scotia, (Sheet 4; Sheets 1, 2 and 3 are in Paper ME 1979-4), by R. R. Stea and J. H. Fowler, scale 1:100 000. **$3.50**

Detailed Scale

1:50 000

OFM ME 1988-52 Preliminary Till Geochemistry and Till Clast Geology of the Windsor Map Sheet (21A/16), South Mountain Batholith Project, by F. J. Boner, P. W. Finck and R. M. Graves, scale 1:50 000. **$2.00**

GEOPHYSICS MAPS

Provincial Scale

1:2 000 000

Map ME 1979-5 to Map ME 1979-9 Folio of Geological Maps of Nova Scotia - includes

Geological, Structural, Metamorphic, Classes of Mineral Deposits, Bouguer Gravity Anomaly and Magnetic Maps, by J. D. Keppie, G. K. Muecke, A. K. Chatterjee and others, scale 1:2 000 000, 1979. **$1.00** (Please note that Geological Map ME 2000-1 is the most recent provincial scale geology map of Nova Scotia)

1:1 000 000

OFM ME 1999-1 Index map to Nova Scotia Department of Natural Resources Bedrock Geology, Surficial Geology and Aeromagnetic Open File Maps of Nova Scotia [scale 1:1 000 000], compiled by K. D. Fraser, 1999, 1 map. **$5.00**

1:500 000

Map ME 1979-3 Geological Map of Nova Scotia, Bouguer Gravity Anomaly Edition, by J. D. Keppie, scale 1:500 000, 1979, with Metamorphic and Structural Map Inserts by J. D. Keppie and G. K. Muecke, scale 1:1 000 000. **$2.50** (Please note that Geological Map ME 2000-1 is the most recent provincial scale geology map of Nova Scotia)

Regional Scale

1:125 000

Map ME 2000-2 Enhanced Aeromagnetic and Digital Elevation Map of Eastern Nova Scotia, compiled by M. S. King, 2000, scale 1:250 000. **$6.00**

Map ME 1983-2 Calculated Vertical Magnetic Gradient Map of the Cape Breton Highlands, Inverness and Victoria Counties, Nova Scotia, scale 1:125 000. **$5.00**

Detailed Scale

1:50 000

OFM ME 1997-33 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 20P/15, Port Mouton, Queens and Shelburne Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-32 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 20P/14, Shelburne, Shelburne and Queens Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-31 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 20P/13, Tusket, Yarmouth and Shelburne Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-30 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 20O/16, Yarmouth, Yarmouth County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-28 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 21A/09, Chester, Lunenburg and Halifax Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-27 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 21A/08, Lunenburg, Lunenburg County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-26 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 21A/07, Bridgewater, Lunenburg and Queens Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-25 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 21A/04, Wentworth Lake, Yarmouth and Digby Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-24 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 21A/03, Lake Rossignol, Shelburne, Yarmouth, Queens and Digby Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-23 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital

Data, NTS Map Sheet 21A/02, Liverpool, Queens and Lunenburg Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-22 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 21A/01, LaHave Islands, Lunenburg County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-21 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11D/12, Halifax, Halifax County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-20 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11F/05, Guysborough, Guysborough and Antigonish Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-19 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11F/04, Country Harbour, Guysborough County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-18 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11F/03 and 11F/06, Larrys River and Chedabucto Bay, Guysborough County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-17 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11E/08, Lochaber, Pictou, Guysborough, and Antigonish Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-16 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11E/04, Kennetcook, Hants County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-15 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11E/03, Shubenacadie, Halifax, Colchester and Hants Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-14 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11E/02, Upper Musquodoboit, Halifax, Guysborough and Colchester Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-13 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11E/01, Liscomb, Guysborough and Halifax Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-12 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11D/16, Ecum Secum, Halifax and Guysborough Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-11 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11D/15, Tangier, Halifax County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-10 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11D/14, Musquodoboit Harbour, Halifax County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-9 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11D/13, Mount Uniacke, Halifax and Hants Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-8 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11D/11, West Chezzetcook, Halifax County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-7 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11D/10, Owls Head, Halifax County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

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Provincial Scale

1:2 000 000

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OFM ME 1997-35 Historic Underground Mining + Advanced Exploration Sites: Abandoned Mine Openings, compiled by Mining Engineering Section, Nova Scotia Department of Natural Resources, September 24, 1997. **$5.00**

Map ME 1991-1 Map of Gypsum and Anhydrite Resources in Nova Scotia, compiled by G. C. Adams, 1991, scale 1:500 000 (accompanies EGS ME 1991-1). **$5.00**

Map ME 1985-1 Industrial Mineral Commodities Map of the Province of Nova Scotia, compiled by John H. Fowler, 1985, scale 1:500 000. **$5.00**

Map ME 1983-5 Metallogenic Map of Nova Scotia, by A. K. Chatterjee, scale 1:500 000, 1983. **$5.00**

Map ME 1983-3 Salt and Potash Resources Map of Nova Scotia, by R. C. Boehner, scale 1:500 000 (accompanies Bulletin ME 5). **$2.00 (white print copies only)**

Map ME 1979-2 Geological Map of Nova Scotia, Metallic Mineral Occurrence Edition, by J. D. Keppie, D. J. Gregory, A. K. Chatterjee and N. A. Lyttle, scale 1:500 000, 1979, with Structural and Metamorphic Map Inserts by J. D. Keppie and G. K. Muecke, scale 1:1 000 000. $2.50 (Please note that Geological Map ME 2000-1 is the most recent provincial scale geology map of Nova Scotia)

Regional Scale

1:250 000

Map ME 1989-3 Map of the Peatland Areas of Nova Scotia, by A. R. Anderson and W. A. Broughm, Sheet 3 (Cape Breton Island), 1986, scale 1:250 000 (accompanies Bulletin ME 6). **$2.00** (white print copies only)

Map ME 1989-2 Map of the Peatland Areas of Nova Scotia, by A. R. Anderson and W. A. Broughm, Sheet 2 (Central Nova Scotia), 1986, scale 1:250 000 (accompanies Bulletin ME 6). **$2.00 (white print copies only)**

Map ME 1989-1 Map of the Peatland Areas of Nova Scotia, by A. R. Anderson and W. A. Broughm, Sheet 1 (Southwestern Nova Scotia), 1986, scale 1:250 000 (accompanies Bulletin ME 6). **$2.00 (white print copies only)**

1:125 000

Map ME 1985-6 Aggregate Resources Map, Cape Breton Island, by W. J. Wright, scale 1:125 000 (locates and shows the type, quality and observed thickness of sand and gravel deposits). **$3.00**

Map ME 1985-3, Map ME 1985-4, Map ME 1985-5 Aggregate Resources Map, Cape Breton Island, by W. J. Wright, scale 1:125 000, (locates and names aggregate pits and quarries). **$3.00 each, $10.00 set**

1:100 000

OFM ME 1986-49 to OFM ME 1986-56 Gold Compilation of the Meguma Terrane in Nova Scotia, by J. McMullin, G. Richardson, T. Goodwin, 8 maps, scale 1:100 000. **$2.00 each**

OFM ME 2001-1 Map of bedrock aggregate potential in the Halifax - Dartmouth metropolitan area, Nova Scotia, by G. Prime. **$5.00**

Detailed Scale

1:50 000

OFM ME 1991-5 to OFM ME 1991-18 Aggregate Potential of Cumberland and Colchester Counties, 14 Preliminary Map Sheets, scale 1:50 000 (11E/02, 11E/03, 11E/05, 11E/06, 11E/07, 11E/11, 11E/12, 11E/13, 11E/14, 21H/07, 21H/08, 21H/09, 21H/10, 21H/16), by G. Prime, 1991. $2.00 per NTS Map Sheet

1:6000

OFM ME 1990-2 Map of the Glencoe Limestone Deposit, Inverness County (11F/14), 1988 Diamond-Drilling; Diamond-Drill Holes and Sections, by R. H. MacDonald, scale 1:6000. **$2.00**

1:1600

Map ME 1990-3 Geological Map of the Canadian Salt Company Limited Pugwash Mine (11E/13A), 830 Level, Pugwash, Nova Scotia, by D. C. Carter, 1990, scale 1:1600. **$5.00**

Map ME 1990-2 Geological Map of the Canadian Salt Company Limited Pugwash Mine (11E/13A), 730 Level, Pugwash, Nova Scotia, by D. C. Carter, 1990, scale 1:1600. **$5.00**

Map ME 1990-1 Geological Map of the Canadian Salt Company Limited Pugwash Mine (11E/13A), 630 Level, Pugwash, Nova Scotia, by D. C. Carter, 1990, scale 1:1600. **$5.00**

1:70

Map ME 1984-1 Geological Map of the Cochrane Hill Open-Pit Gold Deposit, Guysborough County, Nova Scotia, by P. K. Smith, scale 1:70. **$8.00**

STRUCTURE/TECTONIC MAPS

Provincial Scale

1:2 000 000

Map ME 1979-5 to Map ME 1979-9 Folio of Geological Maps of Nova Scotia - includes Geological, Structural, Metamorphic, Classes of Mineral Deposits, Bouguer Gravity Anomaly and Magnetic Maps, by J. D. Keppie, G. K. Muecke, A. K. Chatterjee and others, scale 1:2 000 000, 1979. **$1.00** (Please note that Geological Map ME 2000-1 is the most recent provincial scale geology map of Nova Scotia)

1:500 000

Map ME 1982-11 Tectonic Map of Nova Scotia, by J. D. Keppie, scale 1:500 000, 1982. **$5.00**

LAND USE MAPS

Provincial Scale

1:500 000

OFM ME 2000-1 Land Designation and Ownership in Nova Scotia, researched and compiled by David Hopper, Fred J. Bonner and Brian E. Fisher, 2000, scale 1:500 000. **$5.00**

OFM ME 1997-35 Historic Underground Mining + Advanced Exploration Sites: Abandoned Mine Openings, compiled by Mining Engineering Section, Nova Scotia Department of Natural Resources, September 24, 1997. **$5.00**

1:100 000

OFM ME 2001-2 Map of land use constraints in the Halifax - Dartmouth metropolitan area, Nova Scotia, by G. Prime. **$5.00**

Detailed Scale

1:50 000

OFM ME 1989-5 to OFM ME 1989-9 Mineral Resource Land Use Maps for Lunenburg County, by D. B. Hopper and H. J. Gillis, 1989, 5 maps, scale 1:50 000. **$2.00 per map, $10.00 set**

OFM ME 1988-44 to OFM ME 1988-49 Mineral Resource Land Use Maps for Kings County (21A/10, 21A/15, 21A/16, 21H/01, 21H/01, 21H/02, 21H/08), by D. B. Hopper and H. J. Gillis, 1989, 6 maps, scale 1:50 000. **$2.00 per map; $12.00 set**

OFM ME 1988-33 to OFM ME 1988-38 Mineral Resource Land Use Maps for Cape Breton County, by D. B. Hopper and H. J. Gillis, 1988, 6 maps, scale 1:50 000. **$2.00 per map; $12.00 set**

OFM ME 1988-17 to OFM ME 1988-22 Mineral Resource Land Use Maps for Hants County, by D. B. Hopper and H. J. Gillis, 1988, 6 maps, scale 1:50 000. **$2.00 per map; $12.00 set**

OFM ME 1988-1 to OFM ME 1988-12 Mineral Resource Land Use Maps for Halifax County, by D. B. Hopper and C. A. Dobson, 1988, 12 maps, scale 1:50 000. **$2.00 per map; $24.00 set**

GENERAL MAPS

Provincial Scale

1:2 000 000

Map ME 1979-5 to Map ME 1979-9 Folio of Geological Maps of Nova Scotia - includes Geological, Structural, Metamorphic, Classes of Mineral Deposits, Bouguer Gravity Anomaly and Magnetic Maps, by J. D. Keppie, G. K. Muecke, A. K. Chatterjee and others, scale 1:2 000 000, 1979. **$1.00** (Please note that Geological Map ME 2000-1 is the most recent provincial scale geology map of Nova Scotia)

1:1 000 000

OFM ME 1999-1 Index map to Nova Scotia Department of Natural Resources Bedrock Geology, Surficial Geology and Aeromagnetic Open File Maps of Nova Scotia [scale 1:1 000 000], compiled by K. D. Fraser, 1999, 1 map. **$5.00**

OFM ME 1998-16 Index Map to Geological Survey of Canada Open File Geological Maps of Nova Scotia, 1969-1998, by K. D. Fraser, T. L. Lenfesty, 1998, scale 1:1 000 000. **$2.00**

1:640 000

Outside Publication ME 1989-1 Geological Highway Map of Nova Scotia, Second Edition, by Howard V. Donohoe, Jr., and R. G. Grantham, scale 1:640 000, 1989 (Atlantic Geoscience Society, Special Publication Number 1). **$3.50**

1:500 000

Claim Reference Map (compilation) of Nova Scotia, updated quarterly, scale 1:500 000. **$5.00**

OFM ME 1997-35 Historic Underground Mining + Advanced Exploration Sites: Abandoned Mine Openings, compiled by Mining Engineering Section, Nova Scotia Department of Natural Resources, September 24, 1997. **$5.00**

Detailed Scale

1:31 680

Claim Reference Maps of Nova Scotia, undated, scale 1:31 680. **$1.00 per 1:50 000 NTS Map Sheet Quarter Section**

ACTS

Provincial legislation.

Mineral Resources Act and Regulations, S.N.S. 1990, c. 18. **$9.35**

Gypsum Mining Income Tax Act, R.S.N.S. 1979, c. 190. **$1.00**

Treasure Trove Act, 1954. **FREE**

ANNUAL REPORTS

Summary reports of the Department's activities and programs.

1993/94

Annual Report for the Fiscal Year Ending March 31, 1994, by Nova Scotia Department of Natural Resources, 1995, 89 pages. **FREE**

1992/93

Annual Report for the Fiscal Year Ending March 31, 1993, by Nova Scotia Department of Natural Resources, 1994, 83 pages. **FREE**

1991/92

Annual Report for the Fiscal Year Ending March 31, 1992, by Nova Scotia Department of Natural Resources, 1994, 77 pages. **FREE**

1990/91

Annual Report for the Fiscal Year Ending March 31, 1991, by Nova Scotia Department of Mines and Energy, 1992, 117 pages. **FREE**

BULLETINS

Detailed scientific reports on various geoscience topics on a regional or provincial basis.

Bulletin ME 7 Structure of the Canadian Appalachians, by J. D. Keppie, 1992, 89 pages, 3 maps, 3 figures in back pocket. **$8.00 (Microfiche $2.00)**

Bulletin ME 6 Evaluation of Nova Scotia's Peatland Resources, by A. R. Anderson and W. A. Broughm, 1988, 109 pages, 3 maps, scale 1:250 000. **$15.00**

Bulletin ME 5 Salt and Potash Resources in Nova Scotia, by R. C. Boehner, 1986, 346 pages, 82" x 11" format, includes Map ME 1983-3, scale 1:500 000. **$17.00 (Microfiche $5.00)**

Bulletin ME 4 Barite, Celestite and Fluorite in Nova Scotia, by G. W. Felderhof, 1978, 463 pages, 200 figures, 12 tables. **$13.00**

Bulletin ME 3 Assessment of Peat Moss Occurrences in Guysborough, Antigonish, Pictou, Colchester and Cumberland Counties, Nova Scotia, by D. R. Sutherland and F. S. Shea, 1976, 301 pages. **$7.00**

Bulletin ME 2 (Part 1) Limestones and Dolomites of Nova Scotia, Part I - Cape Breton Island, by F. S. Shea and D. A. Murray, 1969, 300 pages, 1 map. **$4.00**

Bulletin ME 2 (Part 2) Limestones and Dolomites of Nova Scotia, Part II - Antigonish, Guysborough, Pictou, and Cumberland Counties, by D. A. Murray, 1975, 155 pages. **$6.50**

NOTE: For Part 3, Colchester and Halifax Counties, see Open File Report ME 2000-3.

Bulletin ME 1 Port Hawkesbury Project - Geology, Geochemistry and Groundwater Investigations of Southwest Inverness and Richmond Counties, Nova Scotia, by F. S. Shea and J. D. Wallace, 1962, 73 pages, 5 maps. **$2.00**

ECONOMIC GEOLOGY SERIES

Detailed scientific reports on mineral commodities of economic or potential economic interest.

EGS ME 2001-1 Overview of bedrock aggregate potential in the Halifax - Dartmouth metropolitan area, Nova Scotia, by G. Prime, 74 pages, 2 maps in back pocket. **$22.00**

EGS ME 1996-1 Building Stone in Nova Scotia, by G. B. Dickie, 1996, 165 pages. **$10.00 (Microfiche $3.00)**

EGS ME 1992-2 Aggregate Potential of Cumberland and Colchester Counties, Nova Scotia, by G. Prime, 1992, 172 pages. **$10.00 (Microfiche $3.00)**

EGS ME 1992-1 Various Industrial Mineral Commodities in Nova Scotia, by R. H. MacDonald, 1992, 99 pages. **$7.00 (Microfiche $2.00)**

EGS ME 1991-1 Gypsum and Anhydrite Resources in Nova Scotia, by G. C. Adams, 1991, 305 pages, 1 map, scale 1:500 000. **$25.00 (Microfiche $4.00)**

EGS ME 1990-3 Oil Shale Resources of Nova Scotia, by W. D. Smith and R. D. Naylor, 1990, 73 pages. **$12.00 (Microfiche $2.00)**

EGS ME 1990-2 Filler and Extender Minerals in Nova Scotia, by Peter Luke, 1990, 64 pages. **$6.00 (Microfiche $2.00)**

EGS ME 1990-1 Diatomaceous Earth Occurrences in Nova Scotia, by A. R. Anderson, 1990, 132 pages. **$15.00 (Microfiche $3.00)**

EGS ME 1989-1 Properties and Uses of Nova Scotia Clays and Shales, by Susan Gouthro, 1989, 288 pages. **$20.00 (Microfiche $3.00)**

EGS ME 1975-1 Iron Deposits of Nova Scotia, by J. D. Wright, 1975, 154 pages, 1 map. **$6.00**

EGS ME 1974-1 Geology and Trace Element Studies of Manganese Occurrences in Nova Scotia, by D. G. Bishop and J. D. Wright, 1974, 255 pages. **$7.50**

ILLUSTRATIONS

Geoscience diagrams other than maps.

Illustration ME 1998-3 Sydney Mines: Fossil Interpretation Project, by J. H. Calder, 1998, 16" x 21" colour poster. **$12.00**

Illustration ME 1998-2 Brule Fossil Site Project: Preserving and Developing a World Class Fossil Discovery in Nova Scotia, by J. H. Calder, 1998, 16" x 21" colour poster. **$12.00**

Illustration ME 1998-1 The Fossil Cliffs of Joggins: Towards World Heritage Site Designation, by J. H. Calder, 1998, 16" x 21" colour poster. **$12.00**

INFORMATION CIRCULARS

Free promotional pamphlets or booklets on various geoscience topics.

IC ME 60 Properties Available for Option in Nova Scotia, January 2000, by Nova Scotia Department of Natural Resources, 2000, 55 pages. **FREE**

IC ME 58 A Guide to Mineral Exploration Legislation in Nova Scotia, 1998, 8 pages. **FREE**

IC ME 55 Safe Work Methods Handbook, by Minerals and Energy Branch, Nova Scotia Department of Natural Resources, August 1997, 40 pages. **FREE**

IC ME 53 Secondary Processing of Industrial Minerals in Nova Scotia, by Nova Scotia Department of Natural Resources, Minerals and Energy Branch, 1998, 28 pages. **FREE**

IC ME 50 Carbonate-Hosted Zn-Pb-Ba-Ag-Cu Deposits in the Lower Carboniferous of Nova Scotia: The Irish Connection, by D. J. Kontak, 1996. **FREE**

IC ME 49 Ni-Cu-Co Associated with Mafic and Ultramafic Rocks of Cape Breton Island, by G. J. DeMont, 1996. **FREE**

IC ME 48 Cretaceous Kaolin Clay and Silica Sand Deposits in Nova Scotia, by P. W. Finck and R. R. Stea, 1996. **FREE**

IC ME 47 Vein and Breccia Deposits of Fe-Cu-Co-Ni-Ba-Au Associated with the Cobequid-Chedabucto Fault Zone, Nova Scotia, by G. A. O'Reilly, 1996. **FREE**

IC ME 46 Copper Deposits in the Carboniferous Rocks of Northern Nova Scotia, by R. J. Ryan, 1996. **FREE**

IC ME 45 Take Advantage of Mineral Exploration and Development in Nova Scotia, by Nova Scotia Department of Natural Resources, 1996. **FREE**

IC ME 42 A Sign to Watch Your Step, by Mining Engineering Section, Nova Scotia Department of Natural Resources, July 1995. (This information brochure describes hazards associated with abandoned mine sites). **FREE**

IC ME 41 Career Choices in the Petroleum Industry, by Petroleum Resources Section, Nova Scotia Department of Natural Resources, September 1993, 7 pages. **FREE**

IC ME 39 Petroleum Resources Offshore and Onshore Nova Scotia, Canada, by Nova Scotia Department of Natural Resources, Petroleum Resources Section, 1994, 7 pages. **FREE**

IC ME 36 Metalliferous Environments of Nova Scotia: Base Metals, by James M. Patterson, 1993, 18 pages. (This brochure summarizes Information Series ME 22.) **FREE**

IC ME 34 GEOFACTS: Industrial Minerals in Nova Scotia, by Energy, Mines and Resources Canada and Nova Scotia Department of Natural Resources, 1992, revised 1996, 4 pages. **FREE**

IC ME 33 GEOFACTS: Salt in Nova Scotia, by Energy, Mines and Resources Canada and Nova Scotia Department of Natural Resources, 1992, revised 1996, 4 pages. **FREE**

IC ME 32 GEOFACTS: Gypsum in Nova Scotia, by Energy, Mines and Resources Canada and Nova Scotia Department of Natural Resources, 1992, revised 1996, 4 pages. **FREE**

IC ME 31 GEOFACTS: Anhydrite in Nova Scotia, by Energy, Mines and Resources Canada and Nova Scotia Department of Natural Resources, 1992, revised 1996, 4 pages. **FREE**

IC ME 30 GEOFACTS Modelling the Development of Rifted Continental Margins - "Time Travel by Computer", by Energy, Mines and Resources Canada and Nova Scotia Department of Natural Resources, 1992, 4 pages. **FREE**

IC ME 29 GEOFACTS: Canada's Dynamic Coastline, by Energy, Mines and Resources Canada and Nova Scotia Department of Natural Resources, 1992, 4 pages. **FREE**

IC ME 27 GEOFACTS: Using Digital Sound in Marine Geoscience, by Energy, Mines and Resources Canada and Nova Scotia Department of Natural Resources, 1992, 4 pages. **FREE**

IC ME 25 One of the Greatest Treasures: The Geology and History of Coal in Nova Scotia, by J. H. Calder, K. S. Gillis, D. J. MacNeil, R. D. Naylor and N. Watkins-Campbell, 1993, 42 pages. **FREE**

IC ME 24 Industrial Minerals in Nova Scotia, by Nova Scotia Department of Natural Resources, Mineral Development Division, 1992, 25 pages. **FREE**

IC ME 22 Land Use Policy Development Project, by David B. Hopper and Andrew J. Kendall, November 1988. **FREE**

IC ME 21 A Walking Tour of Rocks, Minerals, and Building Stones of Prince Street, Truro, by Jo-Anne Goodwin et al., August 1988. **FREE**

IC ME 18 Peat Moss in Nova Scotia, by A. R. Anderson, 2nd edition, 1993. **FREE**

IC ME 11 A Walking Tour of Rocks, Minerals, and Landforms of Victoria Park, Truro, by Howard Donohoe and Martha Devanney, 1987. **FREE**

IC ME 10 A Walking Tour of Rocks, Minerals and Building Stones along Spring Garden Road, Halifax, by Katherine Bishop, Anne Stevenson, Martha Devanney and Howard Donohoe, 1987. **FREE**

IC ME 9 A Walking Tour of Rocks, Minerals and Landforms of Peggy's Cove, by Anita Sampson and Howard Donohoe, 1987. **FREE**

IC ME 7 A Walking Tour of Rocks, Minerals and Landforms of Point Pleasant Park, by Nova Scotia Department of Mines and Energy, June 1986. **FREE**

IC ME 4 Nova Scotia Gold, by Nova Scotia Department of Mines and Energy, May 1986. **FREE**

IC ME 3 A Walking Tour of Rocks, Minerals, and Building Stones in Downtown Halifax, by Nova Scotia Department of Mines and Energy, April 1986. **FREE**

IC ME 2 Mineral Rights, Landowners, and Mineral Exploration, by Nova Scotia Department of Mines and Energy, February 1986. **FREE**

IC ME 1 Directory of Goods and Services for Exploration Companies, by Shyanne LeBlanc, Trecia Schell, and Howard V. Donohoe, Jr., revised February 1993. **FREE**

INFORMATION SERIES

Promotional booklets on various geoscience topics.

IS ME 24 Twentieth Annual Review of Activities, by Nova Scotia Department of Natural Resources, Minerals and Energy Branch, 1996, 27 pages. **FREE**

NOTE: The Twenty-First Annual Review of Activities continues as Mining Matters in the Report Series.

IS ME 23 Abandoned Mine Openings: Hazards and Remediation Handbook, by Mining Engineering Section, Nova Scotia Department of Natural Resources, July 1995, 90 pages. (This handbook is intended to provide private landowners with information regarding the potential hazards and legal liabilities of abandoned mine openings located on their property, and to describe remedial methods to reduce or eliminate the hazard). **FREE**

IS ME 22 Metalliferous Environments in Nova Scotia, by James M. Patterson, 1993, 59 pages. **FREE**

IS ME 14 Reflection Seismic Coverage of Onshore and Nearshore Nova Scotia 1942-1987, compiled by P. G. McMahon, 1988, 34 pages, 3 maps in back pocket. **$5.00**

IS ME 13 Gold in Nova Scotia, by Jennifer Bates, 1987, 48 pages. **FREE**

IS ME 11 Surface Petroleum Shows, Onshore Nova Scotia, compiled by Gayle Short, March 1986, 33 pages. Out of Print **(Microfiche $1.00)**

IS ME 10 Petroleum Wells and Drillholes with Petroleum Significance, Onshore Nova Scotia, compiled by P. McMahon, G. Short, and D. Walker, January 1986, 194 pages. Out of Print **(Microfiche $2.00)**

MEMOIRS

Comprehensive, detailed scientific reports on the geology of specific areas.

Memoir ME 10 Geology of the Cumberland Basin, Cumberland, Colchester and Pictou Counties, Nova Scotia, by R. J. Ryan and R. C. Boehner, 1994, 222 pages, 155 text figures and back pocket containing 5 pocket figures, and 4 coloured geology maps: Map ME 1990-11, Map ME 1990-12, Map ME 1990-13 and Map ME 1990-14. **$69.00 (Microfiche $6.00)**

Memoir ME 9 Geology of the Loch Lomond Basin and Glengarry Half Graben, Richmond and Cape Breton Counties, Cape Breton Island, Nova Scotia, by R. C. Boehner and G. Prime, 1993, 68 pages, 1 map. (Includes Map ME 1985-2, Geology of the Loch Lomond Basin and Glengarry Half Graben, Nova Scotia, scale 1:50 000). **$8.00 (Microfiche $2.00)**

Memoir ME 8 Geology of the Antigonish Basin, Antigonish County, Nova Scotia, by R. C. Boehner and P. S. Giles, 1993, 132 pages. **$10.00 (Microfiche $3.00)**

Memoir ME 7 The Geology of the George River Series, Cape Breton, Stratigraphy, Structure and Economic Geology, by G. C. Milligan, 1970, 111 photocopied pages, 5 coloured and 2 black/white maps in back pocket: Map ME 1962-1, Map ME 1963-1, Map ME 1963-2, Map ME 1967-1, Map ME 1967-2 and Map ME 1967-3. **$10.00. (Microfiche $3.00)**

Memoir ME 5 Pleistocene Geology of the Annapolis Valley, Nova Scotia, by C. F. Hickox, 1962, 36 pages, 1 map. **$2.00**

Memoir ME 4 The Older Paleozoic of Pictou County, Nova Scotia, by R. H. Maehl, 1961, 109 pages, 1 appendix, 1 map. **$3.00**

Memoir ME 3 The Stratigraphy of the Windsor Group in the Antigonish Quadrangles and the Mahone Bay - St. Margaret's Bay Area, Nova Scotia, by Nathaniel McLean Sage, Jr., 1954, 168 pages. Out of Print **(Microfiche only $2.00)**

Memoir ME 2 Stratigraphy and Paleontology of the Windsor Group (Upper Mississippian) in parts of Cape Breton Island, Nova Scotia, by Maurice C. Stacy, 1953, 143 pages. Out of Print **(Microfiche only $3.00)**

Memoir ME 1 Gypsum and Anhydrite in Nova Scotia, by N. R. Goodman, 1952, 75 pages. Out of Print **(Microfiche only $2.00)**

MISCELLANEOUS PUBLICATIONS

Older reports on various geoscience topics that were originally published without a series title.

MP ME 1975-4 Bibliography of the Geology of Nova Scotia, by D. J. Gregory, 1975, 237 pages. Out of Print **(Microfiche only $4.00)**

MP ME 1975-3 Core Drilling in Nova Scotia with Government Drills, 1967-1971, 49 pages. **$1.00**

MP ME 1975-2 Drilling Logs of Government Core Drills, 1973, by I. MacDougall and D. W. Grimm, 76 pages. **$1.00**

MP ME 1975-1 Drilling Logs of Government Core Drills, 1972, by I. MacDougall and D. W. Grimm, 85 pages. **$1.00**

NOTE: Drilling logs after 1973 are published as part of the Report Series; e.g. Drilling Logs for 1974 are in Report ME 1976-1.

MP ME 1972-4 Geology of the Middle River and Baddeck Forks Map Areas, Victoria County, Nova Scotia, by B. E. Jones and T. G. N. Covert, 1972, 124 pages, 5 maps. **$5.00**

MP ME 1972-3 Clay and Sand Deposit at Elmsvale, Halifax County, Nova Scotia, by J. H. Fowler, 1972, 62 pages, drillhole sections. Out of Print **(Microfiche Only $2.00)**

MP ME 1972-1 Drilling Logs of Government Core Drills, 1971, by C. F. Townsend and D. W. Grimm, 81 pages. **$1.00**

MP ME 1971-1 Drilling Logs of Government Core Drills, 1970, by C. F. Townsend and D. W. Grimm, 71 pages. **$1.00**

MP ME 1970-1 Drilling Logs of Government Core Drills, 1969, by C. F. Townsend and D. W. Grimm, 65 pages. **$1.00**

MP ME 1969-2 Handbook for Companies Planning Offshore Drilling, by Nova Scotia Department of Mines, 1969, 23 pages. **$0.50**

MP ME 1969-1 Drilling Logs of Government Core Drills, 1968 by C. F. Townsend and D. W. Grimm, 58 pages. **$1.00**

MP ME 1968-2 Core Drilling in Nova Scotia with Government Drills, 1871-1966, 176 pages. **$2.00**

MP ME 1968-1 Drilling Logs of Government Core Drills, 1967, by C. F. Townsend and D. W. Grimm, 39 pages. **$1.00**

MP ME 1967-1 Drilling Logs of Government Core Drills, 1966, by C. F. Townsend and D. W. Grimm, 27 pages. **$1.00**

MP ME 1966-3 Metallic Mineral Occurrences Recorded in the Province of Nova Scotia, by Nova Scotia Department of Mines, 1966, 350 pages. **$4.00**

MP ME 1966-1 Drilling Logs of Government Core Drills, 1965, by C. F. Townsend and D. W. Grimm, 55 pages. **$1.00**

MP ME 1965-1 Drilling Logs of Government Core Drills, 1964, by C. F. Townsend and D. W. Grimm, 43 pages. **$1.00**

MP ME 1964-1 Drilling Logs of Government Core Drills, 1963, by C. F. Townsend and D. W. Grimm, 36 pages. **$1.00**

MP ME 1963-1 Drilling Logs of Government Core Drills, 1962, by C. F. Townsend and D. M. MacLeod, 35 pages. **$1.00**

MP ME 1962-1 Drilling Logs of Government Core Drills, 1961, by C. F. Townsend and D. M. MacLeod, 49 pages. **$1.00**

MP ME 1961-1 Drilling Logs of Government Core Drills, 1960, by C. F. Townsend and D. M. MacLeod, 33 pages. **$1.00**

MP ME 1960-1 Drilling Logs of Government Core Drills, 1959, by M. G. Goudge and D. M. MacLeod, 38 pages. **$1.00**

MP ME 1959-1 Drilling Logs of Government Core Drills, 1958, by M. G. Goudge and D. M. MacLeod, 34 pages. **$1.00**

MP ME 1958-2 Possibilities for Occurrence of Petroleum Reservoirs in Nova Scotia, by W. A. Bell, 1958, 177 pages. **$1.00**

NOTE: Drilling Logs prior to 1958 are in Nova Scotia Department of Mines Annual Reports.

NEWSLETTERS

A quarterly newsletter entitled "Nova Scotia Minerals Update" highlighting topical Minerals and Energy Branch and mineral industry news, events, activities and personnel.

Minerals Update, Volume 16, No. 4, Fall 1999. **FREE**

OPEN FILE ILLUSTRATIONS

Unpublished geoscience diagrams other than maps.

OFI ME 1998-2 What's New, Exploration and Development Highlights, compiled by P. W. Finck, W. E. O'Halloran and G. A. Prime, 11" x 17" colour poster. **$2.00**

OFI ME 1998-1 Industrial Minerals, Natural Gas Production in 1998 - New Opportunities, compiled by P. W. Finck, W. E. O'Halloran and G. A. Prime, 11" x 17" colour poster. **$2.00**

OFI ME 1990-4 Detailed Drillhole Correlation, Tatamagouche Area (11E/14), Cumberland Basin, by R. J. Ryan, 1990, scale 1:1538. **$2.00**

OFI ME 1990-3 Detailed Drillhole Correlation, Oxford Area (11E/12), Cumberland Basin, by R. J. Ryan and R. C. Boehner, 1990, scale 1:1177. **$2.00**

OFI ME 1990-2 Stratigraphic Section of the French River - River John Area (11E/11, 11E/14), Cumberland Basin, by R. J. Ryan and R. C. Boehner, 1990, scale 1:1333. **$2.00**

OFI ME 1990-1 Stratigraphic Section of the Joggins Area (21H/09), Cumberland Basin, by R. J. Ryan and R. C. Boehner, 1990, scale 1:2400. **$2.00**

OPEN FILE REPORTS

Unpublished reports on various geoscience topics.

OFR ME 2001-2 Geology of the South Mountain Batholith, Southwestern Nova Scotia, by M. A. MacDonald, 2001, 359 pages, 1 map (includes Map ME 1994-1). **$15.00**

OFR ME 2001-1 Fault-controlled Zinc Mineralization in the Antigonish Highlands, Antigonish and Pictou Counties, Nova Scotia, by G. A. O'Reilly, 2001, 9 pages, 6 coloured figures. **$5.00**

OFR ME 2000-3 Limestones and Dolomites of Nova Scotia, Part 3, Colchester and Halifax Counties, Nova Scotia, by D. A. Murray, 2000, 181 pages, 28 maps. [For Part 1, Cape Breton Island, see Bulletin ME 2, Part 1; for Part 2, Antigonish, Guysborough, Pictou and Cumberland Counties, see Bulletin ME 2, Part 2.] **$15.00**

OFR ME 2000-1 NTS Location, Author and Citation Index to Nova Scotia Department of Natural Resources, Minerals and Energy Branch Assessment Reports, 1996-1999, compiled by Paul D. McCulloch, Sandra Marshall, Norman A. Lyttle and J. Susan Saunders, 2000, 116 pages. **$10.00**

OFR ME 1998-5 Classic Carboniferous Sections of the Minas and Cumberland Basins in Nova Scotia: with Special Reference to Organic Deposits, by J. H. Calder, R. C. Boehner, D. E. Brown, M. R. Gibling, P. K. Mukhopadhyay, R. J. Ryan and D. M. Skilliter; The Society for Organic Petrology, Annual Meeting Field Trip Guide Book, 29-30 July, 1998, 86 pages. **$10.00**

OFR ME 1998-4 Petroleum Occurrence in Drillholes from the Pictou Coalfield, by K. S. Gillis, 1998, 17 pages, 1 fold out coloured map. **$7.00**

OFR ME 1998-1 Minerals and Energy Branch, Nova Scotia Department of Natural Resources, Province of Nova Scotia: An Organization Review, by C. G. Miller, Industry Government Relations Group, 1998, 60 pages. **$5.00**

OFR ME 1997-8 First Annual Nova Scotia Department of Natural Resources/Geological Survey of Canada (Atlantic) Joint Work Plan for Geoscience in Nova Scotia, 1997-1998, by H. Scott Swinden, Nova Scotia Department of Natural Resources, and J. Verhoef, Geological Survey of Canada (Atlantic), 15 pages. (Also available as Geological Survey of Canada Open File 3527). **$2.00**

OFR ME 1997-7 Report on the Diamond Drilling and Geological Investigations of the Steves Road Lead-Gold Occurrence, North Beaverbank, Hants County, Nova Scotia, by R. J. Ryan, 1997, 67 pages, 2 enclosures. **$10.00**

OFR ME 1997-6 Report on a Diamond-Drilling Program, Mile 16 East Road and MacKenzie Road South, Victoria County, Nova Scotia, by G. J. DeMont, 1997, 33 pages, 1 coloured figure. **$5.00**

OFR ME 1997-5 Report on a Diamond-Drilling Program in the North Brook Area, Victoria County, Nova Scotia, by G. J. DeMont, 1997, 17 pages. **$3.00**

OFR ME 1997-4 Core Logs of Drillholes MER-95-1 and MER-95-2, Piedmont and Merigomish Island, Pictou County, Nova Scotia, by K. S. Gillis, 1997, 17 p. **$3.00**

OFR ME 1997-3 Physical and Chemical Analyses of Kaolin from the Musquodoboit Valley, Nova Scotia, Canada, by Minerex Laboratories, Inc., and Industrial Minerals Services, Inc., 1997, 53 p. **$10.00**

OFR ME 1997-1 Late Quaternary Glaciation and Sea-Level Change Along the Atlantic Coast of Nova Scotia, by R. R. Stea, 1997, 219 pages, 31 maps, 2 maps in pocket, (scale 1:80 000 and Map ME 1992-3 scale 1:500 000). This open file report is a reformatted copy of a thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy at Dalhousie University, 1995. **$30.00**

OFR ME 1996-11 Evaluation of 17 Kaolin Samples from the Musquodoboit and Shubenacadie Valleys, Nova Scotia, by S. E. Valji, Minerex Laboratories, Inc., Milledgeville, Georgia, for Nova Scotia Department of Natural Resources, 1996, 13 pages, 11 black and white figures. **$5.00**

OFR ME 1996-9 Mineral Potential Assessment Procedures Using GIS and Expert Modelling Approach, by J. Wang, 1996, 51 pages, 6 coloured. **$25.00**

OFR ME 1996-8 Investigation of Epithermal-Type, Breccia-Hosted Pb-Zn-Ba-Au Mineralization Within the Tobeatic Shear Zone of Southwestern Nova Scotia, by M. C. Corey and R. M. Graves, 1996, 81 pages, 11 coloured, 2 coloured figures in pocket. **$25.00**

OFR ME 1996-6 Diamond-Drill Core Log of Nova Scotia Department of Natural Resources Drillhole WBK 93-1, Whitten Brook, Walton Woods Road, Hants County, Nova Scotia, by R. C. Boehner, 1996, 9 pages. **$3.00**

OFR ME 1996-5 Geology of the Foord Seam and Associated Strata in the Area of the Stellarton Pit Mine, Pictou Coalfield, Stellarton Basin, Nova Scotia, by K. S. Gillis, R. D. Naylor and J. W. F. Waldron, 1996, 23 pages, 1 geology Map, scale 1:5000, 3 figures (one coloured). **$15.00**

OFR ME 1996-3 Cretaceous-Aged Kaolin Clays and Silica Sands in the Shubenacadie and Musquodoboit Valleys, Nova Scotia, Canada, by R. R. Stea, P. W. Finck, S. Pullan and M. C. Corey, 1996, 25 pages, 8 maps. **$17.00**

OFR ME 1996-2 Geology of the Cambridge Cove/ Bramber and Red Head Map Areas 21H/01-Z1, Z3 and 21H/01-Y2, by Dr. R. G. Moore, 1996, 30 pages, 2 geology maps, scale 1:10 000, in back pocket. **$10.00**

OFR ME 1996-1 Zeolite Mineral Assemblages in the North Mountain Basalt, Nova Scotia, by G. Pe-Piper and D. Horton, 1996, 30 pages, 1 colour location map, scale 1:175 000, in back pocket. **$8.00**

OFR ME 1995-6 New Discoveries of Silica Sand and Kaolinite near Brierly Brook, Antigonish County, Nova Scotia, by R. R. Stea, P. W. Finck, G. Prime and G. J. DeMont; 1995, 5 pages. **$2.00**

OFR ME 1995-5 Reprocessing of Nova Scotia Gravity Data from the NSRF Gravity Database (1952-1988), for Mineral Resources Division, Nova Scotia Department of Natural Resources, by K. Howells and E. D. Clarke; 1995, 211 pages, 1 map and 4 discs of gravity data. **$45.00**

OFR ME 1995-3 A Compilation of Geological, Surficial, Geochemical and Geophysical Data along the Tobeatic Shear Zone in the Little Tobeatic Lake and Peter Lake Areas of Southwestern Nova Scotia, by R. M. Graves, 1995, 42 pages, with 14 figures (9 coloured) and 2 maps (1:25 000). **$15.00**

OFR ME 1995-2 Selected Metallic Mineral Occurrences of Cape Breton Island on NTS Map Sheets 11F/09, 11F/10, 11F/15, 11F/16, 11K/01 and 11K/02, Nova Scotia, by G. J. DeMont, 1995, 175 pages. **$15.00**

OFR ME 1995-1 Diamond-Drilling of Rare Element Pegmatites in Southwestern Nova Scotia, by M. C. Corey, 1995, 33 pages, with 10 figures. **$5.00**

OFR ME 1994-26 Preliminary Results of Drilling Quaternary and Cretaceous Sediments near Shubenacadie, Hants County, Nova Scotia, by P. W. Finck, R. R. Stea and D. F. Dwyer, 1994, 35 pages. **$4.00**

OFR ME 1994-23 Gold Mineralization in the Cape Breton Highlands, Nova Scotia, by P. K. Smith and G. A. O'Reilly, 1994, 16 pages. **$3.00**

OFR ME 1994-22 Geology of the Walton-Rainy Cove Brook Map-Area (NTS 21H/01-Z2 and Z4), Hants County, Nova Scotia, by R. G. Moore, 1994, 36 pages, 1 geological map, scale 1:10 000. **$6.00**

OFR ME 1994-21 Compilation of Seabright Resources Inc. Till and Soil Geochemical Data, Nova Scotia, by K. K. Woodman, R. R. Duncan, R. M. Graves, A. B. Hudgins and P. J. Rogers, 1994, 239 pages, 21 sample location maps, scale 1:50 000. **$50.00**

OFR ME 1994-20 Report on U-Pb Geochronology of Avalonian Rocks in Nova Scotia, by Donald W. Davis, 1994, 13 pages. **$3.00**

OFR ME 1994-16 Doughboy Point Drilling Program, Doughboy Point, Guysborough County, Nova Scotia, by R. H. MacDonald, 1994, 39 pages. **$4.00**

OFR ME 1994-15 Magnetic Signature of the Goldenville-Halifax Transition Zone: North Beaverbank, by M. S. King, 1994, 9 pages. **$3.00**

OFR ME 1994-13 Diamond-Drilling of the East Lake Tungsten Occurrence, Halifax County, Nova Scotia (NTS Sheet 11D/15), by M. C. Corey, 1994, 30 pages. **$5.00**

OFR ME 1994-12 Maximizing Investment by Timely Application of Desktop Digital Technology to Mineral Exploration: An Example from Nova Scotia, Canada, by P. J. Rogers, W. P. Jones and L. M. MacKenzie, 1994, 3 pages, includes 1 coloured figure. **$3.00**

OFR ME 1994-11 Recent Gold Discoveries on Cape Breton Island, Nova Scotia, by G. J. DeMont, 1994, 3 pages. **$1.00**

OFR ME 1994-10 Keyword Index to Assessment Reports, Contribution Series, Open Files and Publications for 1991-1993, by Janette M. Vavra and Norman A. Lyttle, 1994, 14 pages of microfiche. **$3.00 (Microfiche only)**

OFR ME 1994-9 Author Index to Nova Scotia Department of Natural Resources, Mines and Energy Branches, Assessment Reports, Contribution Series, Open Files and Publications for 1991-1993, by Janette M. Vavra and Norman A. Lyttle, 1994, 250 pages. **$20.00**

OFR ME 1994-8 NTS Location Index to Nova Scotia Department of Natural Resources, Mines and Energy Branches, Assessment Reports, Contribution Series, Open Files and Publications for 1991-1993, by Janette M. Vavra and Norman A. Lyttle, 1994, 175 pages. **$15.00**

OFR ME 1994-5 Report on Geological Mapping, Mineral Inventory Studies and Diamond-Drilling Surveys at the Rifle Range and Krumrine Quarries, Upper Leitches Creek, Cape Breton County, Nova Scotia, by G. J. DeMont, 1994, 35 pages, 1 map. **$5.00**

OFR ME 1994-4 Magnetic Mineralogy and Susceptibility of the North-Central Meguma Group: Implications for the Interpretation of Aeromagnetic Total Field, First Derivative and Second Derivative, by M. S. King, 1994, 41 pages, includes 7 coloured figures. **$5.00**

OFR ME 1994-3 Multi-Media Geochemical Sur[illegible] of the Dominique (Sn, Zn, Cu) Deposit, (NTS 20O/16), Yarmouth County, Nova Scotia, by P. A. Lombard and F. J. Boner, 1994, 170 pages. **$15.00**

OFR ME 1993-32 The Economic Impact of the Mineral Industry in Nova Scotia, prepared for Energy, Mines and Resources Canada, by Gardner Pinfold Consulting Economists Limited, August 1993, 74 pages. **$7.00**

OFR ME 1993-29 Selected Metallic Mineral Occurrences of Cape Breton Island, Nova Scotia on NTS Map Sheets 11F/09, 11F/10, 11F/15, 11F/16, 11K/01, by G. J. DeMont, 1993, 296 pages. **$15.00**

OFR ME 1992-20 Gold Potential in the Meguma Terrane: New Discoveries Combining Vertical Gradient Aeromagnetics, Biogeochemistry and Till Sampling, (NTS 21A/02 and 11E/08), by Paul K. Smith, Peter J. Rogers, Lyndon Jensen and Colin E. Dunn, 1992, 6 pages, 7 figures. **$2.00**

OFR ME 1992-16 Multi-Media Detailed Geochemical Study of the Brazil Lake Pegmatites (NTS 20P/13), Yarmouth County, Nova Scotia, by M. A. MacDonald, F. J. Boner and P. A. Lombard, 1992, 159 pages. **$15.00**

OFR ME 1992-14 Preliminary Report on Geological, Geochemical, Fluid Inclusion and Isotope Studies of the Gays River Pb/Zn Deposit, Nova Scotia (11E/03B), by Dan Kontak, 1992, 220 pages, includes coloured plates. **$25.00**

OFR ME 1992-10 Selected Metallic Mineral Occurrences of Cape Breton Island, Nova Scotia (NTS 11F/14, 11F/15, 11F/16, 11K/02, 11K/03, 11K/06, 11K/07, 11K/10, 11K/15, 11K/16), by Garth J. DeMont, 1992, 290 pages. **$20.00**

OFR ME 1992-9 Mineralogical Investigations along the Upper Seal Harbour Anticline, Goldboro, Nova Scotia (11F/04D), by M. C. Corey, 1992, 77 pages, includes coloured plates. **$20.00**

OFR ME 1992-8 Geological and Geochemical Observations within the Tangier Gold Deposit (11D/15C), by M. C. Corey and R. F. Mills, 1992, 138 pages. **$15.00**

OFR ME 1992-7 An Evaluation of Debris Avalanches in the Cape Breton Highlands, Nova Scotia, (11K/07 and part of 11K/10), by P. W. Finck, 1992, 68 pages. **$5.00**

OFR ME 1992-3 Multi-Media Detailed Geochemical Study of the Canfield Creek Cu-Ag Deposit, North-Central Nova Scotia, by M. A. MacDonald, 1992, 90 pages. **$9.00**

OFR ME 1991-18 Multi-Media Detailed Geochemical Study of the Yava Lead Deposit - East Zone, by M. A. MacDonald, F. J. Boner and P. A. Lombard, 1991, 162 pages. **$16.00**

OFR ME 1991-16 Selected Mineral Occurrences of the Cumberland and Stellarton Basins and their Metallogenetic Implications, by R. J. Ryan, 1991, 197 pages. **$15.00**

OFR ME 1991-11 Index Maps and Map Data Sheets to Nova Scotia Department of Mines and Energy and Geological Survey of Canada Published and Open File Geochemical Maps of Nova Scotia (compiled to August 1991), by P. L. LeBlanc, N. A. Lyttle, J. M. Freeman, 1991, 165 pages, 2 maps. **$6.00 Maps only; $22.00 complete**

OFR ME 1991-10 Index Map and Map Data Sheets to Published Geological Survey of Canada Coloured Total Field and Vertical Gradient Aeromagnetic Maps of Nova Scotia (compiled to

August 1991), by Patricia L. LeBlanc, Norman A. Lyttle, Janette M. Freeman, 1991, 50 pages, 1 map, scale 1" to 16 miles (1:1 013 760). (This Open File Report supersedes Open File Report ME 1990-15). **$2.00 Map only; $7.00 complete**

OFR ME 1991-9 Index Map and Map Data Sheets to Published Nova Scotia Department of Mines and Energy and Geological Survey of Canada Surficial Geology Maps of Nova Scotia (compiled to August 1991), by Patricia L. LeBlanc, Norman A. Lyttle, Janette M. Freeman, 1991, 36 pages, 1 map, scale 1" to 16 miles (1:1 013 760). (This Open File Report supersedes Open File Report ME 1990-14). **$2.00 Map only; $5.50 complete**

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OFR ME 1991-2 Selected Metallic Mineral Occurrences of Cape Breton Island on NTS Map Sheets 11F/14, 11K/01, 11K/02, 11K/06, 11K/07, by Garth DeMont, 1991, 200 pages. **$15.00**

OFR ME 1990-24 A Study of Pits and Quarries Rehabilitation, prepared for Energy, Mines and Resources Canada, Mineral Policy Sector, by Gardner Pinfold Consulting Economists Limited in association with Robert Parker Associates Limited, Peter Klynstra Landscape Architects Limited, 1990, 146 pages. **$10.00**

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OFR ME 1990-19 Summary of the Major Limestone - Dolomite Deposits of Nova Scotia, by R. H. MacDonald, 1990, revised edition of Nova Scotia Department of Mines and Energy Open File Report ME 1986-64. **$3.00**

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OFR ME 1990-8 Quaternary Geology of Nova Scotia, compiled by R. R. Stea and R. J. Mott; Guidebook for 53rd Annual Friends of the Pleistocene Field Excursion, May 25-28, 1990, 85 pages, 61 figures. **$11.00**

OFR ME 1990-7 Lithogeochemistry of the Western Portion of the South Mountain Batholith, Nova Scotia (21A/03, 21A/04, 21A/05, 21A/06, 21A/11, 21A/12, 21A/14), by L. J. Ham, M. C. Corey, R. J. Horne and M. A. MacDonald, 1990, 30 pages, 3 maps, scale 1:150 000 and 1:250 000. **$7.00**

OFR ME 1990-6 Trace Element Analysis of Till (-230 Mesh), South Mountain Batholith, (11D/05, 11D/12, 11D/13, 20P/13, 21A/03, 21A/04, 21A/05, 21A/06, 21A/07, 21A/09, 21A/10, 21A/11, 21A/12, 21A/14, 21A/15, 21A/16, 21H/02), by F. J. Boner, P. W. Finck and R. M. Graves, 1990, 40 pages, 1 map, scale 1:250 000. **$6.00**

OFR ME 1990-5 Heavy Mineral Till Geochemistry (Tin) of the Western South Mountain Batholith, by P. W. Finck, F. J. Boner and R. M. Graves, 1990, 40 pages, 3 maps. **$12.00**

OFR ME 1990-4 Heavy Mineral Till Geochemistry (Tin) of the Eastern and Central South Mountain Batholith, by P. W. Finck, F. J. Boner and R. M. Graves, 1990, 21 pages, 3 maps, scale 1:250 000. **$10.00**

OFR ME 1989-7 Geochemical Analyses of Bulk Stream Sediment Samples from Northern Nova Scotia, by R. F. Mills, 1989, includes many tables and 3 sample location maps, scale 1:250 000. **$40.00**

OFR ME 1989-6 Summary Report on Quarry Stone Used in the Construction of Dominion Building, Halifax, N. S., by G. B. Dickie, 1989, 16 pages. **$3.00**

OFR ME 1989-5 Open File Report on Selected Mineral Occurrences of the Cobequid Area, Nova Scotia, (NTS 11E/05, 11E/06, 11E/10, 11E/11, 11E/12, 21H/07, 21H/08), by K. E. Northcote, G. DeMont and A. Armitage, March 1989, 189 pages, many tables. **$15.00**

OFR ME 1989-4 Open File Report on Selected Mineral Occurrences of Southern Cape Breton Island, Nova Scotia, (NTS 11F/10, 11F/15, 11F/16, 11K/01, 11K/02), by K. E. Northcote, G. DeMont and A. Armitage, March 1989, 94 pages, tables. **$10.00**

OFR ME 1989-3 Open File Report on Selected Mineral Occurrences of the Antigonish Area, (NTS 11E/08, 11E/09 and 11E/16), by K. E. Northcote, G. DeMont and A. Armitage, February 1989, 184 pages, tables. **$15.00**

OFR ME 1989-1 Lithogeochemistry of the Eastern Portion of the South Mountain Batholith, Nova Scotia, (Map Sheets 11D/05, 11D/12, 11D/13, 21A/09, 21A/10, 21A/15, 21A/16, and parts of 21H/01 and 21H/02), by L. J. Ham, S. W. Marsh, M. C. Corey, R. J. Horne and M. A. MacDonald, 62 pages, 2 maps. **$15.00**

OFR ME 1988-63 An Assessment of the Hydrocarbon and Compressed Air Storage Potential of Nova Scotia: A Summary, by Nolan, Davis and Associates Ltd., 1988, 22 pages. **$3.00**

OFR ME 1988-59 Interpretation of Till Geochemical Data in Nova Scotia, Canada, Using Mapped Till Units, Multi-Element Anomaly Patterns, and the Relationship of Till Clast Geology to Matrix Geochemistry, by R. G. Turner and R. R. Stea, 1988, 39 pages. **$5.00**

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OFR ME 1988-55 Multi-Element Ratings Maps for Meguma Zone Lake Sediments, by P. J. Rogers, 1989, 34 pages, 3 maps. **$5.00**

OFR ME 1988-40 Aggregate Market Study for New Brunswick and Nova Scotia, by ADI Limited, 1988, Prepared for Mineral Policy Sector, Energy, Mines and Resources Canada, 309 pages. **$17.00**

OFR ME 1988-39 Marine Transport Study for Nova Scotia, by Leslie MacIntyre Maritime Associates Inc., May 1988, Prepared for Mineral Policy Sector, Energy, Mines and Resources Canada, 38 pages. **$5.00**

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OFR ME 1987-2 Market Analysis for New Brunswick, Nova Scotia and Newfoundland Dimension Stone, by the DPA Group Incorporated in association with Jacques Whitford and Associates Limited, March 1987, 66 pages. **$10.00**

OFR ME 1986-54 The U.K. Experience on the Effects of Offshore Sand and Gravel Extraction on Coastal Erosion and the Fishing Industry, by R. Warren Drinnan and Douglas G. Bliss, Dobrocky Sea Tech Limited, August 1986, 90 pages. **$10.00**

OFR ME 1986-39 Agricultural Gypsum Project, by Peter Luke, 1986, 9 pages. **$3.00**

OFR ME 1986-25 The Gypsum Industry in Nova Scotia - Present Status and Future Prospects, by R. E. Wright and J. H. Brown; prepared for Nova Scotia Department of Mines and Energy by Centre for Resource Studies, Queen's University, 1985, 125 pages. **$15.00**

OFR ME 1986-21 Compilation of Drillhole Information from Open Assessment Reports Available to the End of December 1985: Western Nova Scotia (Map Sheets 20O, 20P, 21A, 21B, 21H), 235 pages. **$10.00**

OFR ME 1986-20 Compilation of Drillhole Information from Open Assessment Reports Available to the End of December 1985: Eastern Nova Scotia (Map Sheets 11F, 11G, 11J, 11K, 11N), 355 pages. **$10.00**

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OFR ME 1986-12 A Study of Industrial Minerals Used in Oil and Gas Exploration on the Eastern Canadian Offshore, by Jacques, Whitford and Associates, and Cleland, Dunsmuir Consulting Limited, 231 pages. **$17.00**

OFR ME 1986-10 Study of Markets for Aggregate Materials Accessible from Nova Scotia and New Brunswick, by ADI Limited, March 1986, 398 pages. **$10.00**

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OFR ME 656 The Development Potential for Nova Scotia's Offshore Aggregate and Placer Resources, by John Fowler and Craig Miller, 1985, 69 pages. **$10.00**

OFR ME 651 Gypsum Property, Ownership and Leases, by Mark W. G. King, 1985, 140 pages. **$10.00**

OFR ME 650 Guide to the Granites and Mineral Deposits of Southwestern Nova Scotia, edited by A. K. Chatterjee and D. B. Clarke, 1985, 264 pages. **$15.00**

OFR ME 648 Current Market Economics of the Strontium Minerals by Metals Economic Group of Halifax, Nova Scotia, and Boulder, Colorado, 1985, 54 pages. **$5.00**

OFR ME 621 Effects of Location on Mine Development Potential: Nova Scotia's Competitive Position in Canada, by D. W. Davis, B. W. MacKenzie and M. L. Bilodeau, 1985, 103 pages. **$15.00**

OFR ME 608 Industrial Mineral Occurrences Map and Data Compilation, Western Nova Scotia (Map Sheets 20O, 20P, 21A, 21B, 21H), by M. Ponsford, G. DeMont and N. A. Lyttle, 1985, 21 pages, 1 map. **$4.00**

OFR ME 607 Industrial Mineral Occurrences Map and Data Compilation, Eastern Nova Scotia (Map Sheets 11F, 11G, 11J, 11N), by M. Ponsford, G. DeMont and N. A. Lyttle, 1985, 29 pages, 1 map. **$4.00**

OFR ME 606 Industrial Mineral Occurrences Map and Data Compilation, Central Nova Scotia (Map Sheets 11D, 11E), by M. Ponsford, G. DeMont and N. A. Lyttle, 1985, 22 pages, 1 map. **$4.00**

OFR ME 605 Regional Lake Sediment Survey of the Meguma Zone, Southern Nova Scotia: New Analytical Data, by P. J. Rogers, M. A. MacDonald and D. W. Rigby, 1985, 65 pages, 2 maps. **$5.00**

OFR ME 603 Preliminary Feasibility Study for an Underground Gold Mining Operation in Central Nova Scotia, by Nova Scotia Department of Mines and Energy, 1984, 62 pages, 2 maps. **$5.00**

OFR ME 601 Metallic Mineral Occurrences Map and Data Compilation, Western Nova Scotia (Map Sheets 20O, 20P, 21A, 21B, 21H), by M. Ponsford and N. A. Lyttle, 1984, 21 pages, 2 maps. **$3.00**

OFR ME 600 Metallic Mineral Occurrences Map and Data Compilation, Eastern Nova Scotia (Map Sheets 11F, 11G, 11J, 11K, 11N), by M. Ponsford and N. A. Lyttle, 1984, 23 pages, 2 maps. **$3.00**

OFR ME 599 Metallic Mineral Occurrences Map and Data Compilation, Central Nova Scotia (Map Sheets 11D and 11E), by M. Ponsford and N. A. Lyttle, 1984, 21 pages, 2 maps. **$3.00**

OFR ME 329 The Glencoe Limestone and Dolomite Survey, by D. J. MacNeil, 1977, 252 pages, 12 maps. **$15.00**

OFR ME 50 Carboniferous Stratigraphy and Economic Geology, Halifax, Hants and Colchester Counties, Nova Scotia; Canadian Institute of Mining and Metallurgy, Geology Division, Field Guide, by Mining Society of Nova Scotia, Atlantic Geoscience Society and Nova Scotia Department of Mines, 1974, 48 pages. **$1.00**

OUTSIDE PUBLICATIONS

Various externally published reports and maps on geoscience topics authored by non-Minerals and Energy Branch staff.

OP ME 2001-1 The Last Billion Years: A Geological History of the Maritime Provinces of Canada, by Atlantic Geoscience Society, 2001. Atlantic Geoscience Society Special Publication No. 15. **$29.95**

OP ME 1998-2

A Special Issue Devoted to Lead-Zinc Mineralization and Basinal Brine Movement, Lower Windsor Group (Viséan), Nova Scotia, Canada; in Economic Geology and the Bulletin of the Society of Economic Geologists, v. 93, September-October 1998, no. 6, 260 pages. **$21.00**

OP ME 1998-1

Discovering Rocks, Minerals and Fossils in Atlantic Canada, A Geological Field Guide to Selected Sites in Newfoundland, Nova Scotia, Prince Edward Island, and New Brunswick, edited by P. Wallace, 1998, 186 pages; Atlantic Geoscience Society, Special Publication No. 14. **$25.00**

OP ME 1995-1 Proceedings: 30th Forum on the Geology of Industrial Minerals (1994), edited by S. A. A. Merlini, 1995; New Brunswick Department of Natural Resources and Energy,

Minerals and Energy Division, Miscellaneous Report 16, 261 pages. **$14.75**

OP ME 1991-1 A Guide to the Geology, Landscapes and Mineral Resources of Nova Scotia, by Craig K. Miller and G. C. Milligan, 1991; Atlantic Geoscience Society, Special Publication No. 6 (Preliminary Edition), 188 pages. **$5.00**

OP ME 1988-1 Atlantic Geoscience Society, Colloquium '88, Antigonish, N. S. (Abstracts of Papers). **$4.00**

OP ME 1987-2 The Mining Society of Nova Scotia 1887-1987, by D. Pigot, published by the Mining Society of Nova Scotia, June 1987, 125 pages. **$10.00**

OP ME 1987-1 Quaternary Glaciations, Geomorphology and Sea Level Changes: Bay of Fundy Region, by R. R. Stea, Field Trip, July 19-30, 1987, for NATO Advanced Study Institutes Programme, International Advanced Course on Late Quaternary Sea Level Correlations and Applications, Halifax, Nova Scotia; 79 pages. **$10.00**

OP ME 1986-5 Trip No. 14 Lithostratigraphic, Physical Diagenetic and Economic Aspects of the Pennsylvanian-Permian Transition Sequence of Prince Edward Island and Nova Scotia; H. W. van de Poll, J. R. DeGrace, R. J. Ryan, 1986; in Geological Association of Canada/Mineralogical Association of Canada Guidebooks for Field Excursions (Fredericton, May 15-17, 1985). **$7.00**

OP ME 1986-4 Trip No. 11 Turbidite-Hosted Gold Deposits, Meguma Domain, Eastern Nova Scotia; P. K. Smith, S. J. Haynes, B. E. Jones, 1986; in Geological Association of Canada/Mineralogical Association of Canada Guidebooks for Field Excursions (Fredericton, May 15-17, 1985), 67 pages. **$7.00**

OP ME 1986-3 Trip No. 10 Igneous and Metamorphic Geology of the Cape Breton Highlands; S. M. Barr, R. A. Jamieson, R. D. Raeside, 1986; in Geological Association of Canada/Mineralogical Association of Canada Guidebooks for Field Excursions (Fredericton, May 15-17, 1985), 48 pages. **$5.00**

OP ME 1986-2 Behind the Headlines: Moose River to Shangri-La, by Ralph Kelly Morton, 1986; in Geological Association of Canada/Mineralogical Association of Canada Guidebooks for Field Excursions (Fredericton, May 15-17, 1985), 197 pages. **$14.95**

OP ME 1986-1 Trip No. 1 Appalachian Geotraverse (Canadian Mainland); J. D. Keppie, K. Currie, J. B. Murphy, et al., 1986; in Geological Association of Canada/Mineralogical Association of Canada Guidebooks for Field Excursions (Fredericton, May 15-17, 1985), 181 pages. **$15.00**

OP ME 1981-1 Malagash Salt, compiled and edited by John R. MacQuarrie, c. 1975, 1981, 109 pages. **$5.00**

PAPERS

Detailed scientific papers on specific geoscience topics and/or specific areas.

Paper ME 1997-1 The Geology of a Portion of the South-Central Cape Breton Highlands (part of NTS map sheet 11K/07), Victoria and Inverness Counties, Nova Scotia, by L. J. Ham, 1997, 43 pages, 1 coloured map, includes Map ME 1997-1, scale 1:25 000 in back pocket. **$15.00**

Paper ME 1995-2 Geology of the South-Central Cape Breton Highlands (Parts of NTS Sheets 11K/07 and 11K/10), Inverness and Victoria Counties, Nova Scotia, by R. J. Horne, 61 pages, includes Map ME 1995-2 in back pocket. **$20.00**

Paper ME 1995-1 The Compositional Development of Tills Overlying the South Mountain Batholith, Nova Scotia, by P. W. Finck and R. R. Stea, 1995, 52 pages, includes Map ME 1992-2. **$15.00**

Paper ME 1994-1 A Diamond-Drilling Program near the Amherst Market, Investigating Bedrock Aggregate Potential in the Northwestern Cobequid Highlands, Nova Scotia, by G. Prime, 1994, 38 pages. **$4.00**

Paper ME 1993-2 Quaternary Stratigraphy and Placer Gold Potential of the Inner Scotian Shelf, by R. R. Stea, S. Pecore and G. B. J. Fader, 1993,

62 pages. **$7.00 (Microfiche $2.00)**

Paper ME 1993-1 An Evaluation of Debris Avalanches in the Central Cape Breton Highlands, Nova Scotia, by P. W. Finck, 1993, 65 pages. **$9.00 (Microfiche $2.00)**

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Paper ME 1989-1 Metallogenic Studies of Southeastern Cape Breton Island, by A. S. Macdonald, 1989, 99 pages, 3 figures in pocket. **$20.00 (Microfiche $3.00)**

Paper ME 1986-1 Cretaceous Deposits of Nova Scotia, by G. B. Dickie, 1987, 54 pages. **$15.00 (Microfiche $3.00)**

Paper ME 1985-2 The Formation of Veins in Greenschist Facies Rocks and the Early Deformation of the Meguma Group, Eastern Nova Scotia, by B. H. O'Brien, 1985, 35 pages. **$3.00 (Microfiche $1.00)**

Paper ME 1984-1 Petrology of Granitoid Rocks of the Boisdale Peninsula, Central Cape Breton Island, Nova Scotia, by S. M. Barr and J. R. D. Setter, 1986, 75 pages, includes Map ME 1984-2 folded in back pocket. **$8.00 (Microfiche $2.00)**

Paper ME 1982-2 Metasomatic-Hydrothermal Mineral Deposits of the New Ross - Mahone Bay Area, Nova Scotia, by G. A. O'Reilly, E. J. Farley and M. H. Charest, 96 pages. **$5.00 (Microfiche $1.50)**

Paper ME 1982-1 Geology and Geochemistry of Selected Granitoid Plutons of Cape Breton Island, by S. M. Barr, G. A. O'Reilly and A. M. O'Beirne, 176 pages, 44 figures, 13 tables. **$8.00 (Microfiche $2.00)**

Paper ME 1981-4 Principles of Tectonic Mapping Based upon Plate Tectonic Theory, by J. D. Keppie, 11 pages. **$1.50 (Microfiche $1.00)**

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Paper ME 1979-7 Carbonate Banks of the Gays River Formation in Central Nova Scotia, by P. S. Giles, R. C. Boehner and R. J. Ryan, 57 pages, 1 map. **$4.00**

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REPORTS

Various geoscience publications such as bibliographies, compilations, drill log summaries, indexes, Report of Activities.

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Report ME 2001-1 Minerals and Energy Branch Report of Activities 2000, edited by D. R. MacDonald, 2001, 179 pages. **$15.00**

Report ME 2000-2 Mining Matters for Nova Scotia 2000: Opportunities for Economic Development, edited by D. R. MacDonald, 2000, 42 pages. **$5.00**

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DP ME 48. Map of Bedrock Aggregate Potential in the Halifax - Dartmouth Metropolitan Area, Nova Scotia, 2001, compiled by G. Prime, scale 1:100 000. Open File Map ME 2001-1	PDF	3 Mb	FREE DOWNLOAD
DP ME 47, Mineral Resource Land-Use (MRLU) Maps, Nova Scotia, version 1, 2000, compiled by D. B. Hopper, F. J. Bonner, B. E. Fisher and A. N. Murphy, scale 1:50 000. Open File Maps ME 2000-4.	PDF	93 Maps from 0.2 Mb to 13 Mb	FREE DOWNLOAD
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D94-08. Geological Map of Bridgetown, Nova Scotia [21A/14], [1:5000], version 1, 1997, compiled by M. A. MacDonald and L. J. Ham, 1994 (line work only, no point data)	E00 DXF/DBF	360 Kb 587 Kb	FREE DOWNLOAD
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DP 005. Airborne gamma ray spectrometric survey images, elemental and elemental ratio images covering 11D, 11E, 11F, 11G, 11J, 11K, 11N, 20O, 20P, 21A, 21B and 21H), version 1, 1997 (250 m x 250 m resolution).	TIFF	14 Mb	FREE DOWNLOAD
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DP 008. Meguma Terrane enhanced second vertical derivative aeromagnetic digital data, version 1, 1997. Includes: (a) images in TIFF format of the aeromagnetic data from OFM's 97-7 to 97-28 and 97-30 to 97-33, without topographic base information or legends; (b) contractor's report on the processing methodology; (CD-ROM product only) (c) plot files in HP-GL/2 format of OFM's 97-7 to 97-28 and 97-30 to 97-33; (CD-ROM product only)	TIFF	573 Mb, CD-ROM 123 Mb, WEB	$10.00
DP 011 Enhanced Aeromagnetic and Digital Elevation Image of Eastern Nova Scotia, Version 1, 2000, M. S. King, (25 m x 25 m, 40 m x 40 m, 80 m x 80 m resolutions)	TIFF JPG PDF	101 Mb/12.9 Mb/ 3.3 Mb, CD-ROM 6.7 Mb/3.4 Mb/ 1.1 Mb 6.9 Mb	$10.00

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